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SCIENCE

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MSS. intended for publication and books, etc., intended for review should be sent to the responsible editor, Professor J. McKeen Cattell, Garrison-on-Hudson N. Y.

*ADVANCES IN METHODS OF TEACHING.**

ZOOLOGY.

By *advances in teaching* I understand the use of desirable methods not now generally employed, for while the common methods of this generation are advances over those of a preceding one a discussion of this fact could have no possible value and only an historical interest to us.

I take it that the common method of teaching zoology is by means of laboratory work supplemented by lectures or recitations, and, further, that both teacher and institution are well equipped for this work; these are prerequisites, the need of which need not be emphasized here. Beyond and in addition to these common provisions what advances in teaching zoology are both possible and desirable? Many minor features might be considered, such as certain improvements in laboratory and museum methods, the best sequence of subjects, the relations of lectures to laboratory work, etc.; but I prefer to emphasize two, and only two, main features, viz.: (1) the relations of research to teaching, and (2) the study of the whole of zoology.

I. One of the greatest possible advances in teaching zoology would be the promotion of research work in all institutions of college or university grade and the establishment of the closest possible relations be-

* Discussion before the New York meeting of the American Naturalists and Affiliated Societies, December, 1898.

tween teaching and research. Advances in teaching must be, in the main, founded upon advances in research. Objects which every beginner in zoology sees and studies to-day were known to only a few investigators ten years ago. Methods which are common property now were then being worked out for the first time. The interest and value of teaching is directly proportional to the teacher's acquaintance with original sources of knowledge. The all too common method of leaning—or rather riding—upon a text-book violates the whole laboratory idea, and the more advanced custom of relying upon original papers without making any attempt to see the things described is but little better. Every teacher should endeavor to see and know for himself, and to give his students opportunity to see and know the classical objects upon which important doctrines of zoology rest.

But the relation of the teacher to research should not be merely that of a *hearer* of the word, but of a *doer* also. Research work on the part of the teacher and, if possible, by at least a few advanced students should be a part of the *teaching equipment* of every college and university. Too frequently and indiscriminately has it been maintained that the qualities which make a man a good investigator ruin him as a teacher. The examples of Agassiz, Huxley, Leuckart and many others, both here and abroad, show how erroneous is such a view. Great ability as an investigator may be united with qualities which are ruinous to the teacher, but these are not qualities essential to research. On the other hand, a good teacher must be, at least to a certain extent, an investigator also. The ability to make a subject plain is not the first nor, indeed, the most important function of a college or university teacher ; his first duty is to arouse interest in his subject, to direct students to reliable sources of information and to encourage them in independent work. For all of these purposes research is of the utmost value. A new fact discovered in a laboratory is a stimulus to faithful and independent work, such as nothing else in the world can be; whatever other requirements colleges and universities may make upon their teachers, they might safely require that they be contributors to knowledge. The greatest mistake which a college or university teacher can make is to talk and act as if his science were a closed and finished one. A subject which seems old and stale to the teacher will seem uninteresting and unimportant to the learner. To the teacher who has only a text-book knowledge of things all subjects soon seem finished, fixed, bottled and labelled; once a year, perhaps, he wearily exhibits these dead and changeless things before his suffering class. But the teacher who realizes how little we know about any subject and how much remains to be learned—who, while accurately presenting what is known, can by both precept and example help to extend the bounds of knowledge—will never find his subject stale nor his class uninterested.

It will be objected that in many subjects and in most institutions such a course is impossible. Undoubtedly it is more difficult to make discoveries in some fields than in others, but it is one of the particular charms of the biological sciences that the opportunities for research here are greater than in most other subjects. The great amount of teaching and of administrative work which is required of many teachers is the greatest obstacle to this plan; and yet I know persons who teach from twenty-five to thirty hours a week and who yet find time to do research work, if in no other way, at least by keeping their eyes open for new points in the material used in their classes.

It is sometimes maintained that there is a fundamental difference in kind between graduate and undergraduate teaching, and

that the former alone can have any relations to independent work or research, while the latter must consist of information courses merely. But whatever may be true of other subjects, it is certain that biological studies encourage and develop independence in observations and reflections from the beginning. I maintain, even at the risk of being charged with holding low ideals of graduate work, that the distinction between graduate and undergraduade work in biology is one of degree and not of kind. Of course, elementary students cannot do research work of any great value, and yet they may catch the spirit of research and assist in carrying out work of importance. Some valuable work of the last few years has grown out of the careful and independent study, in undergraduate classes, of the structure, development and variations of well-known animals. The knowledge that new facts may be discovered even in elementary work is an inspiration to both student and teacher. I pity the man who has to teach a finished science; I wonder how either he or his students stand it. The zoologist has here an advantage which he cannot afford to throw away. If it is further objected that this method would induce students to neglect well-known facts in ridiculous attempts to find new ones, or that it would assist an ignorant or lazy teacher to fill up gaps in his information by ingenious speculations, I can only reply that such an abuse should be credited to the teacher and not to the system. The thesis which I defend is simply and comprehensively this: The spirit of zoological teaching should be the inquiring, independent, alert spirit of research.

II. Another advance not less important than the one just emphasized would be found in increased facilities for studying the whole of zoology. The time was when zoology meant merely classification; at present it means little more than morphology; a great advance will have been made we all realize, and succeed in getting our institutions to realize, that these subjects, however important, are but a part of zoology and that a large and important field is still almost unoccupied. The usual laboratory work in zoology, viz.: the anatomy of a few alcoholic specimens, is less than one-half of the science and in all respects the least interesting and important half. Research to-day is tending more and more to the study of *living* things, and in this respect, as in so many others, research points out the way for advances in teaching. The study of living animals; of their actual development under normal and experimentally altered conditions; of their food and the manner of getting it; their enemies and friends, parasites and messmates; their mating, breeding and care of young; the effects of isolation, crossing and close breeding on structure and habits; the effects of varying light, color, temperature, density of medium, etc., on color, size and structure of every part; the daily and nightly activities of animals; the origin and nature of peculiar habits and instincts—in short, the study of all the varied ways in which animals live and adapt themselves to their environment is an integral part of zoology; and who can doubt that together these things form its most important part, and yet there are few if any places where any systematic attempt is made to give instruction in these subjects.

Practically the only attempt which is made in most institutions to meet these needs is by means of field work. The value of such work cannot be overestimated and it must always remain an indispensable part of any broad zoological training, but it is not in itself sufficient. In large cities and during the colder part of the year it is especially difficult to carry on field work, and in no case is it possible to have animals under observation for considerable periods

of time or to carry on experiments with them in the field. Field work must consist largely of collection, classification and scattered observations; more serious work must be transferred to the laboratory.

A most useful and important adjunct to zoological teaching is an animal house, or vivarium, in which may be found fresh and salt-water aquaria; terraria for small land forms; hives for bees, ants and other insects; rooms for various amphibia, reptiles, birds and small mammals; hatcheries for the eggs of various vertebrates and invertebrates, and various appliances for the experimental study of living animals. Such a vivarium might contain a synoptic collection of living animals, worth vastly more for teaching purposes than the ordinary museum or laboratory. Botanists have long recognized the necessity of greenhouses for teaching purposes, and the need of having living material for study is quite as great in zoology as in botany. Some such vivarium is a necessity if zoology is to be studied in any broad way. It is usual in building laboratories to provide an animal room in some small, dark corner of the cellar, while the whole of the building proper is devoted to lecture rooms, laboratories and museums. It is sad to think that such a disposition of space represents the popular view of the importance of the study of living animals. In a very important sense a vivarium is the most essential part of any laboratory of zoology, representing that for which all the rest exists. In cases where it is not possible to have a separate building or large, well-lighted rooms for this purpose a greenhouse and animal house could be combined; and in all cases a few well-stocked ponds in the immediate vicinity of the laboratory can usually be provided without trouble or expense, which will furnish a never-failing supply of living material.

But under the most favorable circumstances the number of living animals which can be kept in or near the laboratory is not large; for making extensive studies on large numbers of animals, recourse must be had to experimental farms and to marine and fresh-water stations. Little has yet been done in the way of establishing experimental farms for purposes of pure science, though I believe they are destined to play a very important part in the development of our science in the future, but the establishment of biological stations has done more to advance the study of zoology than any other one thing in this generation. While the laboratory, the vivarium and perhaps also the experimental farm are things which each university must provide for itself, the marine and fresh-water stations can reach their greatest usefulness through the cooperation of many institutions. Without in any way disparaging the work done by other stations of a similar kind, I think it may truthfully and modestly be said that the Woods Holl Station, in the measure of cooperation which it represents; in the close relations which there exist between teaching and research, and in the fullness with which the whole of zoology is represented, has done more to advance the teaching of zoology in this country than has any other institution or factor. The professor of anatomy in one of our best medical schools said to me a few days ago: "In all my teaching I try to follow the general methods employed in the classes at the Woods Holl Laboratory; those methods are models of good teaching." If this can be said for the teaching of human anatomy how much more is it true of the studies which are there directly represented. Some of the greatest possible advances in teaching zoology will be found in realizing in every college and university the Woods Holl ideal.

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ANATOMY.

It is not too broad a statement to say that the modern methods of teaching anatomy reflect the general progress of that science during the past decade. In the limited time at my disposal I am only able to accentuate some of the main facts as they pertain to instruction in human anatomy. In this branch the revolution in the spirit and method of our teaching is primarily based on the recognition of man's scientific position in the vertebrate series. We have ceased, as teachers, to regard the human body as a thing apart and by itself, and the study of its structure and of the functions of its parts is no longer attempted without the aid which comparative anatomy and embryology so abundantly offer. The truths embodied in the doctrine of evolution have long furnished the quickening spirit of scientific morphological study and research, but their full utilization by the teacher of human anatomy as his most valuable guides is of so comparatively recent date that I feel justified in citing their pedagogic adoption as the most important and fundamental advance in late years in the methods of anatomical instruction.

It is so evident that every complete organism is only fully comprehended in all its relations when the method of its production and development is known, and the fact that the simplest conditions offer the logical starting point in learning or teaching complicated structural details is so in accord with our daily experience, that the disregard of phylogeny and embryology by teachers of human anatomy seems little short of incomprehensible. And yet in my own experience as a teacher of human anatomy I remember grave academic deliberations as to the propriety of placing the study on the scientific basis which we occupy to-day, and some doubtful queries as to whether after all it would not be more advisable to uphold the traditional method, somewhat as the Moslem Kadis have continued to teach the Koran since the day of Mahomet. Human anatomy, considered from the standpoint of the instructor, has coursed through a curious cycle since Vesalius in the 14th century raised it to the dignity of a science.

From the point where he left it the knowledge of man's structure continued to develop during the succeeding centuries. The details of human gross anatomy were elaborated until every minute portion of the human frame received its complete description, and at least one more or less appropriate and lengthy name. The teaching of the science progressed along the same lines, and the increase in the details of descriptive anatomy found its response in the anatomical text-book. Edition succeeded edition, each containing somewhat more erudite and minute information than its predecessor, and this accumulated mass of facts confronted the student at the outset of his course. It is not remarkable that under these conditions the important fundamental structural lines of the subject were obscured and overshadowed by the quantity of detail, nor that the study of anatomy appeared to resolve itself into a more or less successful effort at memorizing the largest possible quantity of facts without special regard to their quality or importance.

I well remember in my own student days that every man with any pretensions to anatomical prowess could glibly and accurately describe the five surfaces of the orbital process of the palate bone and give their boundaries, but I doubt if many of us realized that said process was extremely lucky if it attained the size of a respectable pea, and a still smaller minority would have passed with credit through a practical demonstration on the skull. In the same way the knowledge that the artery of the vas deferens arises from the superior vesical was a never-failing source of satisfaction to

its possessor, while a student who faced west on Madison Square had no occasion to strain his descriptive faculties in the least in order to enumerate the Fifth Avenue Hotel in its correct position among the structures related to his common carotid artery. But the morphological connection and the mutual relation existing between prosencephalon and diencephalon, the principles governing the development and structure of the lung and vascular system, the disposition of the peritoneal membrane, and many like problems, were regarded in much the same light.

What knowledge of these structures the student obtained he gained in the most difficult manner,.by a pure effort of memory. He had no constructive details at his command, no series of stages which, while demonstrating the road by which a complicated human structure reached its highest degree of development or regression, enabled him at the same time to grasp and hold the details of that structure as a permanent and lasting addition to his knowledge, not as facts memorized and hence to be forgotten. In this sense teaching by comparison and development marks our most important and fundamental advance in methods of instruction. That this advance will be progressive lies in the very essence of its character. We all recognize the practical importance of careful descriptive detail in teaching human anatomy. But in striving after the necessary accuracy and elaboration the minutiæ should not be permitted to obscure and hide the broad morphological and functional principles which underlie the construction of the animal body.

They, after all, form the fundamental lines upon which the student must build his anatomical knowledge if the same is to be enduring, and these lines, if once firmly established, readily and logically permit the addition of the necessary details. The function of comparative anatomy and embryology, as aids in the teaching of human anatomy, is to define clearly and demonstrate, beyond question or doubt, the cardinal morphological principles upon which the structure of the vertebrate body is reared. I can merely refer in passing to the development of the equipment necessary to the vitality and success of the method. Perhaps no other single fact accentuates the advances in morphological education more than the change which is to be observed in the spirit and purpose of the anatomical museum. It has ceased to be a storehouse for a heterogeneous association of curios, and has assumed its proper place as an important factor in scientific education, presenting the cardinal structural and functional principles of the vertebrate body in concrete serial form. From a collection it has become a library in which he who runs may read.

While we are justified in characterizing this fundamental change in the spirit and conception of anatomical instruction as our most pronounced methodical advance in recent years, a number of other improvements are entitled to your consideration. Hardly secondary in importance to the principle of the comparative and developmental method of teaching is the application of the principle in practice. I need not detain this audience with illustrative examples, which will suggest themselves, but I may be permitted to emphasize the fact that we have advanced materially in substituting true object-teaching for theoretical instruction. Perhaps nowhere more than in anatomy is lasting and valuable knowledge gained only by direct and personal examination of the object of the study.

Not only have our courses in practical anatomy increased in the time and material required and improved in the application of a thorough test by practical examination, but we have carried the same cardinal principle of sound anatomical instruction into

the details of the didactic course. It is probably true that, under proper conditions of environment, a parrot could be taught a hymn, for we have proof of his power in acquiring a secular vocabulary. In the same way, undoubtedly, a student can be taught a certain kind of anatomy by lecture, diagrams and models. But I question whether he will find this knowledge much more useful than the parrot his hymn. Assimilation of anatomical knowledge requires demonstration of the actual structures, to a limited number of students, for the purpose of enabling each to see and examine the objects themselves with which he is to become familiar, not models or diagrams. "I asked for bread and they gave me a stone" —or a model—is a saying which no student of anatomy should have occasion to apply to his own case.

This reason has led to the replacement of the didactic lecture by the section demonstration. I still concede to the lecture, modified and supplemented by demonstration, an important function in furnishing the orderly, logical and systematic presentation of the subject which is to serve as the guiding thread in the student's individual examination of the structures. It is the proper place for the elaboration of the broad morphological principles of vertebrate structure, but these should be illustrated and emphasized by the direct examination of the structures involved. The lecture should indicate clearly the main facts of which the student is to satisfy himself by personal observation in the demonstration. Both conducted side by side are mutual supplements.

Such, in brief, I conceive to be the main factors in the advance of anatomical teaching. Many secondary aids, such as the complete pedagogic separation of elementary and advanced students, the modern methods of preservation of material, the improved technique of preparations, the introduction of elective and optional courses in general morphology and others would demand consideration if more time were at our disposal.

But, however brief and insufficient my presentation of the subject may appear, teachers of anatomical science feel that the advance along the lines indicated is a material gain and that, under the broad spirit of our universities, it will be progressive.

GEO. S. HUNTINGTON.

PHYSIOLOGY IN MEDICAL SCHOOLS.

THE paper which I have had the honor of preparing for this occasion consists of three parts; the first gives a critical review of the present unsatisfactory methods of teaching physiology in medical schools (in which institutions most of the physiological teaching is done); the second presents a detailed proposal for instruction in accordance with what are believed to be correct pedagogical principles; and the third discusses ways and means, and demonstrates that the proposed changes are within the present means of any successful school. The time allotted to each speaker requires the omission of the critical account of present methods and the discussion of ways and means. Only the second part of the paper can be given here.*

The picture I have drawn of the instruction in physiology in medical schools will not be challenged by teachers of that science. The sense that our methods of instruction neither develop nor much inform the mind is general. It is time that discussion of the difficulties and the way to remedy them should also be general. Physiology is the most highly developed rational discipline in medicine—not a merely descriptive science like anatomy and is well adapted to train the mind in scientific procedure, in the setting of problems for research, in the

* The full paper is printed in the *Boston Medical and Surgical Journal*, December 29, 1898.

criticism of methods and results, and in the tests which lay bare shallowness—matters of great moment to men who shall practice an applied experimental science in the midst of quackery, illusion and pretence. Careful inquiry should therefore be made to determine how far defects of instruction can be remedied with the means at our disposal. The problem is: How far can the correct theory be realized in practice? To what extent can medical students of physiology be taught in the manner in which men are trained to be professional physiologists? Evidently physiologists are likely to study their own subject in the most profitable and labor-saving way.

Much can be done to reconcile theory to practice, but not everything. The size of physiology has broken it into specialties. Even professional physiologists can no longer have personal acquaintance with the whole subject or even a relatively large part of it. The truth of this will be obvious when it is remembered that since January 1, 1894, more than three hundred researches have been published on the physiology of the heart alone. To a considerable degree the physiologist himself must acquire his information from reading the work of others. It would therefore be idle to expect the student of medicine to get a personal experimental knowledge of the whole subject. He has but a year for physiology and must share that time with anatomy. Grave economic laws demand this time shall not be lengthened, and the day of self-support postponed. The time which he now has must be used chiefly for training and not chiefly for the acquisition of facts, as at present, and this training must follow the lines laid down by physiologists for their own development.

The way of the physiologist is not peculiar. The method of getting a real education is the same from the kindergarten to the specialist. The principle is to train 'for power,' to use President Eliot's phrase, and not primarily for information. Deal so far as possible with the phenomena themselves and not with descriptions of them. Use as the basis of professional instruction the facts and methods which shall be used by the student in earning his living. Teach the elements by practical work. Associate facts which the student can observe for himself with the facts which he cannot observe. Control the progress of the student, remove his difficulties, and stimulate him to collateral reading by personal intercourse in the laboratory, by occasional glimpses of the researches in progress in the laboratory, and by daily conferences or seminaries. Give the student careful descriptions of the method of performing his experiments, but require him to set down the results for himself in a laboratory notebook, which, together with the graphic records of his experiment, is to form a requirement for the Doctorate. Choose one sufficiently limited field in which experimental work shall be thorough and comprehensive, affording a strong grasp of that special subject. Add to this the typical, fundamental experiments in other fields.

When the student has come thus far, let him choose one of several electives affording advanced training in the physiology of the medical specialities, such as opthalmology, laryngology, the digestive tract, the nervous system, etc. These courses should be thorough, should contain the physiology required of the best specialists, and above all should deal with nature directly. For example, in studying the physiology of the stomach, the gastric juice should be taken with the stomach-tube directly from the human object, and not obtained merely by adding hydrochloric acid to scrapings of the mucous membrane of swine. This special instruction should be directed by distinguished specialists. Thus the student will be brought into contact with that which will

interest him most, the every-day methods of the best physicians, and the specialist will keep his own foundations in repair. It is in connection with these courses that didactic lectures should be given. Up to this point in his work the student is not ripe. Let there be one to four lectures of not more than forty-five minutes, the subject very limited, so that each set shall present all the existing knowledge on the subject. The purpose of these lectures is to show the student the historical development of scientific problems, the nature of scientific evidence, and the canons of criticism that shall help him to sift the wheat from the chaff of controversy. Lectures of this kind cannot profitably be given by men who have not made experimental investigations in the subject of the lecture; so far as practicable they should be given by the specialists who advise the physiological staff concerning the special courses.

Each student should be required to present one written discussion of some very small and sufficiently isolated thesis, giving the work of the original investigators, together with any observations the student has made for himself. The way of dealing with the sources at first hand will thus be learned.

The student's reading should be correlated strictly with his practical work and should be done in the laboratory in connection with that work. It should not be memorizing, as at present, but the study of graphic records, physiological-anatomical preparations and other physiological material, with the aid of the text-book. The corrections necessary to bring the book up to date and to correlate it with the practical work can be furnished in printed or mimeographed notes.

Such are the lines along which sound theory directs that the teaching of physiology in medical schools should proceed. With such a training the student can safely find his way through the constantly augmenting horde of facts and draw vicarious profit from those who are face to face with the mysteries of nature. Such instruction meets also the needs of men intending to make a profession of biological sciences other than medicine. It will be observed that the course offers: (1) thorough experimental acquaintance with one field, say the physiology of nerve and muscle, giving the point of view, the general physiological method, training in technique, a basis of analogy, adequate knowledge of one living tissue and thus the elements of all; (2) the fundamental elementary experiments in the remaining fields; with the key which the first course gives, these will unlock much; (3) thorough experimental acquaintance with one special subject; (4) various complementary gains, of which may be mentioned experience in reaching the original sources and in marshalling facts, a certain degree of skill in the methods used by practitioners, direct correlation between physiology and practical medicine. Much might be said of the value of this group, particularly of the correlation just mentioned, but we must hasten on to the demonstration of how these ends are to be attained practically.

The first problem to be solved in planning instruction is whether the student's time is to be given wholly or only in part to the subject taught. Men in training for professional physiology commonly concentrate their energies for a sufficient period on this one subject, and this is regarded as the most economical way of mastering any science, for the ground gained by one day's work is still fresh in the mind when the next day's work begins, and continuity of thought is not disturbed. The plea that the instruction in one subject should be broken by the injection of other subjects in order that the instruction in each may have 'time to sink in' need not be entertained;

experience shows that much of it sinks in so far that it cannot be got up again without the loss of valuable energy. A more serious objection is that the method of continuous application is highly fruitful in the case of men of exceptional powers, who are keen in spite of protracted effort, but is wasteful for the average brain, which is fatigued and unreceptive after some hours of unremitting labor. The truth of this must be allowed, but the objection does not apply to wide-ranging sciences, such as anatomy and physiology, which are not narrow, hedged-in areas, but which consist rather of broad and diversified domains composed of many contiguous fields, the varied nature of which is a perpetual refreshment. In practice the student of anatomy may divide his time between general anatomy, descriptive human anatomy, histology and embryology, all of which are now taught in the medical curriculum, and the student of physiology may pass from general and special physiology to physiological chemistry, thus resting the mind without interrupting the continuity of effort essential to instruction that must be both rich and frugal.

I would propose, then, that the first year in medical schools be divided equally between anatomy and physiology, the first four months being given to general anatomy, descriptive human anatomy, histology and embryology; the second four to physiology and physiological chemistry, studies which cannot be pursued without a knowledge of anatomy.

In accordance with the principles already outlined, the instruction in physiology should be divided into three parts. Part I, of five weeks' duration, should consist of a thorough drill in the physiology of nerve and muscle, the hours from 9 to 11 being devoted to experiments, the hour from 11 to 12 to study of materia physiologica (physiological preparations, graphic records, etc.), and the time from 12 to 12:45 to a conference or seminary, which should be part lecture, part recitation. In the conference the bearing of the experimental work just done should be developed by systematic progressive questioning accompanied by running comments, to clear up any possible fog. A brief account of other experiments which add to the truth established by those which the student has done for himself, but which are too complex or too protracted to lie within the student's powers, should be brought in here.

Part II, of seven weeks' duration, should comprise carefully-arranged fundamental experiments giving in turn the elements of each field in physiology except that of nerve and muscle, which has just been studied. As before, the whole class works from 9 to 11 upon experiments, from 11 to 12 studies all possible means of illustrating the subject of the day, and from 12 to 12:45 attends the conference or seminary. In the forty-two days covering this part of the course instructors who find the mixture of lecture and Socratic method unsympathetic may abandon their questioning and fill the time with their own remarks; even such instruction would be far more fruitful than the present lectures, for the student would have had experience in anatomy and would be well grounded in experimental physiology, through his work on nerve and muscle, before the talk began; but the seminary is much more effective than the lecture.

In Part III, covering the remaining four weeks of the term, the instruction is divided into special courses on the physiology of the eye, ear, larynx, digestion, the spinal cord, the innervation of the heart, etc. Each course should consist of experimental work from 9 to 11, the study of preparations and other aids from 11 to 12, and a conference from 12 to 12:45. Each course should be long enough to include all the practicable experiments that should find a

place in a systematic, thorough study of the subject. The number of such experiments, and hence the length of the special courses, will naturally be very different in the various instances; thus experimental physiology of the eye will occupy more time than the physiology of the larynx. As many courses should be given at one time as there are instructors in the department. The student may elect the subjects that most interest him, but must choose a sufficient number to occupy him during the entire four weeks of instruction.

The afternoons of the days on which physiology is taught are devoted to physiological chemistry.

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PSYCHOLOGY.

THE invitation to talk about the methods of teaching psychology was to me in one way very welcome. All the year long I have done nothing with fuller conviction than to tell the psychologists that they ought not to meddle with methods of teaching, as they can hardly offer any aid. But there is one exception, and here I have at last a welcome chance to make the necessary appendix to my year's sermon; the psychologists ought not to trouble themselves with the methods of teaching which the other men apply, but they ought, in the highest degree, look out for the methods which they use themselves, as there is perhaps no science in which bad methods are so confusing and dangerous.

But the invitation came also as an embarrassment. The methods of psychology, on account of the many changes in recent years, have so far not had the time to crystallize; they have not reached the stage of an objective form about which the psychologists themselves agree, and it is a hopeless task to seek there anything which is more than a reflex of personal experiences. I felt this difficulty strongly and cannot offer, therefore, anything but an expression of my subjective convictions, which can claim in their favor nothing but the fact that they are based on observations in a university where the rather uncritical rush towards psychology has reached unexpected proportions.

The time is too short to demonstrate here, what even every outsider ought to know, that a scientific psychology is to-day in first line experimental psychology and that collections of instruments are thus the necessary, full laboratories the desirable background of teaching psychology. The audience, on the other hand, is here too various to allow a description of special important pieces of apparatus. I want, therefore, to emphasize merely questions of principle.

Such a question of principle it is to ask which place this experimental psychology ought to have in the lecture courses of the university. To say the experimental work ought to be the whole is absurd; that is possible for physics or physiology, but it is impossible for psychology. The physical sciences start with fundamental conceptions and presuppositions which are acknowledged without difficulty, while in psychology just the basal conceptions like consciousness, psychical causality, psychical elements, psychophysical parallelism are full of difficulties and certainly not open to experimental treatment. The usual way now is that the elementary treatment of mental life deals with this general theoretical book-psychology, while the more advanced lecture courses go forward to an exact experimental study of the special facts.

This seems to me a methodological blunder; the order ought to be just the opposite. I think, firstly, that the treatment of the theoretical questions in psychology is of no value whatever if it is given in an elementary way; every problem leads here to epistemological discussions which go far

beyond a sophomoric mind, and which are not simplified by avoiding the difficulties, but trivialized and falsified. Theoretical psychology is an advanced course for seniors and graduates. On the other hand, I think that experimental psychology can never be the object of a really advanced treatment in a lecture course. In physics or physiology the lecturer can reach the most advanced points because he can follow up the most difficult problems under scientific discussion with his experiments ; not so in psychology. We must not forget that a psychological experiment is nothing but self-observation under artificial conditions. The lecture room cannot produce the conditions for any careful self-observation of every student beyond the most elementary questions. We can produce tone-sensations or color-sensations, or associations and space judgments, in a rough way for the whole class. If we try more we can do two things. Either we make demonstrations on one subject—for instance, reactions; then the whole class may see the person on whom the experiment is made, but the one person is really the only one who goes through the experience of the experiment; it is an illusion to think that the others get the advantage of the experiment too because they are in the same room. Or we choose experiments which every one can make individually at the same time —for instance, touch sensations; but it is clear that here only the most elementary problems are in question. Thus, wherever we come to a more complicated experimental question, the possibilities of the lecture room are at an end, and we have either to talk about experiments without making them—certainly a very bad scheme—or we have to shift them over to the laboratory courses, the only correct way. No other experimental science can come into this troublesome situation, because no other deals with self-observation, but we psychologists ought to confess that the experimental work of the lecture room cannot go beyond the first elements of psychology, and is of a simplicity that every high school boy can understand. We must give up the pose that our psychological work becomes difficult on the introduction of a chronoscope and a kymograph and a color wheel. It is logically endlessly simpler than even the slightest serious discussion of theoretical psychology.

Of course, I am speaking of experimental psychology, which must not be confused with physiological psychology. The latter, in its narrower sense dealing with mind and brain, is either a theoretical discussion of the psycho physical parallelism, and as such fully dependent upon philosophical arguments and independent of empirical observations, or it is a study of the special localizations and functions of the brain parts. The first belongs to advanced theoretical psychology; the second does not belong to a student's course on psychology at all, but to physiology. It is mere coquetry if we decorate our real psychological courses with physiological bric-a-brac.

My method of teaching psychology in Harvard is as follows: I give a large elementary course in psychology which hardly mentions the brain, but which is from the beginning to the end an experimental course, and it is our special aim to construct instruments on a large scale, allowing every student in the audience to go through the self-observational experience of the simple experiments. Theoretical problems are there not discussed, but only touched. Those who have passed this elementary course have now no opportunity to cover the same experimental ground once more in advanced lecture courses, hearing three decimals where at first only one was given. No, they have two alternatives before them. They either enter the laboratory or they go on with lectures called 'advanced psychology,' hearing there hardly a single word about experiments,

and certainly never seeing an instrument in the lecture room. The advanced course is a theoretical discussion of the fundamental conceptions in psycholgy. The course is very difficult, but the fact that about one hundred advanced students take the course this year shows sufficiently how earnestly they feel the need, in our time—in which a thoughtless playing with psychology has become the fad of society—of discussing the principles of that science from a higher standpoint, and not only as a superficial introduction into experimental psychology.

Those who are interested in the details of the experimental work and want to follow it beyond the first elements which the lectures offered enter the training course in the laboratory, performing a prescribed set of individual experiments, working in groups of two. The question how far this training course ought to lead offers again methodological difficulties. We tried different schemes. My assistants gave last year two courses, the first training merely in well-known experiments, the second training in the scholarly attitude of the psychological investigator by carrying out some small investigations from which no gain for science was expected. This year we have dropped the second course and welcome every one, already after a-half year's elementary training course, to the regular original research work of the laboratory, in which, of course, everything is adapted to the effort to work towards the progress of science. We have come to this shorter circuit because with regard to the pedagogical value of original research work psychology has again quite an exceptional position; the self-observation factor, which stands in the way of the experimental work in the lecture room, becomes the greatest advantage for the psychological education in the research work. In physics or physiology you take the part of the investigator or you are outside; in psychology you can take a different part—you may be the investigator or the self-observing subject. And this subject part is, as every experiment is self-observation, in no way a less important and less scientific factor of the research, and yet it is still free from the administrative responsibilities of the investigator who carries on the experiment. To work for a time as subject in different investigations—every student of my laboratory takes part in at least three different investigations of different fields—is thus the very best bridge between the simple training course and the work which points towards publication and the Ph. D. My advice is thus to open the doors of the research laboratory rather earlier than the other exact sciences would wish to do; to work under constant supervision some time as subject seems to me even a better preparation than any special training course. The psychological seminary finally has to accompany this highest stage by advanced debates and papers; this work, in Professor James' hand, alternates in Harvard between more general questions and problems of abnormal psychology. The only defect which I must regret in this scheme is that we have so far no specialists for animal, child and social psychology. Child psychology finds a refuge in the department of pedagogy, social psychology in the department of sociology. They find in many universities to-day a very large amount of good will in both departments, but—and that is the last methodological principle which I wish to lay down—good will alone is also for psychological studies not always sufficient.

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ANTHROPOLOGY.

ANTHROPOLOGY is one of the subjects that have been added to the university curricu-

lum quite recently. For this reason I will devote my remarks to a consideration of the field that anthropological instruction is intended to cover and of its relations to allied sciences rather than to a discussion of methods of instruction.

According to purely theoretical definitions, anthropology is the science of man and might be understood to cover a vast range of subjects. The physical as well as the mental characters of man may be considered in a certain way as the proper field of anthropology. But sciences do not grow up according to definitions. They are the result of historical development. The subject-matter of anthropology has been accumulated principally by travellers who have made us acquainted with the people inhabiting distant countries. Another part of the subject-matter of anthropology is due to the investigation of prehistoric remains found in civilized countries. Only after certain methods had developed which were based largely on the information thus collected was the white race made the subject of investigation.

For this reason the aim of anthropology has been largely to explain the phenomena observed among tribes of foreign culture. These phenomena are naturally divided into three groups: (1) the physical appearance of man; (2) the language of man, and (3) the customs and beliefs of man. In this manner three branches of anthropology have developed: (1) somatology, or physical anthropology; (2) linguistics, and (3) ethnology. Up to this time anthropological investigation has dealt almost exclusively with subjects that may be classed under these three headings. These subjects are not taken up by any other branch of science, and in developing them anthropology fills a vacant place in the system of sciences.

The treatment of these three subjects requires close cooperation between anthropology and a number of sciences. The investigation of the physical characteristics of man has also been taken up by anatomists, but the point of view of the anatomist and that of the anthropologist are quite different. While the former is primarily interested in the occurrence of certain modifications of the human form and in their genetic interpretation, the anthropologist is interested in the geographical distribution of varieties of form, in the variability of the human species in different areas and in their interpretation. The thorough study of physical anthropology, or somatology, requires the combined training of the anatomist and of the anthropologist.

In the study of linguistics the anthropologist deals with a subject that has been partially taken up by the student of special linguistic stocks. The study of the structure of the Aryan languages, of the Semitic languages and of the Mongol languages has been carried on with great success by philologists; but the anthropological problem is a wider one—it deals with the general question of human language.

In the study of ethnology the field of investigation of the anthropologist adjoins that of the field of research of the psychologist and of the sociologist. The development of a truly empirical psychology makes it necessary to draw largely upon material furnished by anthropological studies. On the other hand, sociologists have found that the analysis of the culture of civilized society cannot be carried out successfully without a comparative study of primitive society, which is the subject-matter of anthropological research.

The method of anthropology is an inductive method, and the science must be placed side by side with the other inductive sciences. Our conclusions are based on comparisons between the forms of development of the human body, of human lan-

guage, of human activities, and must be as truly inductive as those of any other science. By including psychology and anthropology in the present discussion on the methods of teaching science, we have given expression to the conviction that the method of investigation of mental phenomena must be no less an inductive method than that of physical phenomena.

The teaching of anthropology may be made to supplement in many ways the teaching of allied subjects, and I will briefly outline its functions in the university curriculum.

Physical anthropology has come to be primarily a study of the varieties of man. The differences between different types of man, defined either geographically or socially, are slight—so slight, indeed, that the biologist, until quite recent times, would have disregarded them entirely. Slight differences in type have been of importance to the student of anthropology at an earlier time than to the student of zoology, because we are more deeply interested in the slight differences that occur in our own species than among animals. This has led to the result that in anthropology sooner than in zoology the insufficiency of description was felt. Anthropology was the first of the biological sciences to substitute measurement for description and the exact number for the vague word. The method of measuring variable phenomena—in the case of anthropology, of the variations composing a type—had to be developed. It is only natural that in the course of this development mistakes were committed which had to be rectified, and that the sound method of metric description developed slowly. It would seem that at present we have reached the stage where the methods of metric description may be clearly recognized, and we may, therefore, expect confidently a rapid and wholesome development of physical anthropology. A glance at recent biological literature shows very clearly that descriptive zoology and descriptive botany are passing at present to the substitution of metric description for verbal description that took place in anthropology some time ago. The study of anthropological methods may prevent biologists from repeating the same errors that were committed in the early days of anthropology. Anthropological subjects will, for a long time to come, remain the most available material for metrical studies of variations in the higher forms of life, because the material can be obtained in greater numbers and with greater ease than in studies of most of the higher animal forms. The metric method, which is at present principally an anthropological method, will, in a very short time, become of great importance to the student of biology, who ought, for this reason, to profit by the experiences of the anthropologist.

The fuller development of physical anthropology will lead to a study of the physiology and experimental psychology of the races of man. But in these lines of work we have hardly made a beginning. The relation of these inquiries to physiology and to psychology will be the same as that of physical anthropology to anatomy.

I may be allowed to pass by briefly the relations of the linguistic method of anthropology to other sciences. You will recognize at once that this subject, as well as its methods, must have a stimulating effect upon the teaching of philology, because its conclusions are based upon the broad grounds of human language; not on the studies of a single family of languages. The science of linguistics is growing slowly on account of its intrinsic difficulties. These difficulties are based as well on the lack of satisfactory material as on the amount of labor involved in the acquisition of knowledge in its particular line of research. Work in this field is most urgently needed,

because the languages of primitive man are disappearing rapidly, thus depriving us of valuable material for comparative study.

Ethnology, the last division of anthropology, covers a vast field. Its main object may be briefly described as the discovery of the laws governing the activities of the human mind, and also the reconstruction of the history of human culture and civilization. The methods applied by ethnologists are twofold. The investigation of the history of the culture of definite areas is carried on by means of geographical and of archæological methods. The methods are geographical in so far as the types inhabiting a country, their languages and their customs, are compared to those of neighboring tribes. They are archæological in so far as they deal with the prehistoric remains found in the country in question. In this case we apply inductive methods for the solution of historical questions. The investigation of the laws governing the growth of human culture is carried out by means of comparative methods, and is based on the results of the historical analysis referred to before. These laws are largely of a psychological nature. Their great value for the study of the human mind lies in the fact that the forms of thought which are the subject of investigation have grown up entirely outside of the conditions whice govern our own thoughts. They furnish, therefore, material for a truly comparative psychology. The results of the study of comparative linguistics form an important portion of this material, because the forms of thought find their clearest expressions in the forms of language.

It appears, from these brief statements of the scope and methods of anthropological research, that an acquaintance with the whole field is indispensable for the sociologist; that a knowledge of results and methods will be of advantage to the psychologist, and that the statistical method developed in physical anthropology will be very helpful to the student of biology. In a general way, a knowledge of the outlines of anthropology seems to be of educational value, particularly in so far as it broadens the historical views of the student, because it extends his view over cultures and civilizations that have grown up uninfluenced by our own. The advances made by our own race will appear to him in a truer light when he is able to compare them with the work done by other races, and if he understands how much our own civilization owes to the achievements of people who appear to be at present on a low level of culture. The methodological value of the teaching of anthropology lies in the fact that it shows the possibility of applying inductive methods to the study of social phenomena.

Franz Boas.

BOTANY.

There are some phases of botanical teaching that do not belong in the present discussion. University teaching, where selected, well-trained, devoted students pursue original investigation under the criticism and advice of great specialists, is excluded, for there is here no question of methods, but only of men. It represents the ideal relation of teacher to student, the true ideal for all botanical teaching. We have in this country some, but far too little of it. Again, college work proper, consisting in advanced thorough courses upon the practicum plan and in the investigation spirit, hardly belongs here. Such work has been stimulated by university example to a high degree of excellence, and in botany much of it is being done to-day in our colleges, a fact with an important bearing upon our present subject, for thus are being trained the teachers of the near future who are to elevate the teaching of the schools. But in the teaching of systematic elementary courses in botany, where these are not

under the direct control of teachers educated thoroughly and in the modern spirit, that is, in the elementary courses in many of the smaller colleges and in most high schools, there are questions and problems enough. Just here lies the center of discussion, effort and advance in methods of botanical teaching at the present time. Below the high schools, in primary and grammar grades, where systematic courses in the sciences are wisely not attempted, but a foundation is laid for them in continuous and thorough courses of 'Nature Study,' there are problems, too, but of a simpler sort, whose solution will follow upon the solution of those of the high school. Just as university teaching has elevated college teaching, both through example and through training teachers for it, just as in the same manner it is college teaching to-day that is elevating high-school teaching, so in the future will good high-school teaching improve that of the lower grades.

In describing the quality of most elementary botanical teaching I would not call it bad, but simply insufficient. It is not true that it commonly teaches error, or is useless as training, but it is true that it is far behind and unrepresentative of the present state of the science. This backwardness is illustrated in many ways, of which I shall mention but two. First, it is, as a study, low in public opinion, good public opinion, which regards it as synonymous with the study of the names of flowers, and hence as a discipline peculiarly fitted to the minds of school girls, or as an appropriate hobby for elderly persons of leisure. Second, it has stood low in the estimation of many university and college authorities, as shown by their frequent neglect to provide for its proper teaching, while amply providing for the sister science zoology, and some of the leading universities have not considered it as of particular value as an element in training in biology. It must be confessed that these opinions are in the main just. Botany, as taught, has been too much the study of the names of flowers, and it has had very little to contribute of value for biological training. The reason for this backwardness is plain enough and most instructive—it is the result of an almost exclusive cultivation of a single phase of the science, entailing an abortion of other phases and an inability of the whole to respond elastically to the science as it broadens. This one phase has been classification of the higher plants, a phase determined by the overpowering influence of Dr. Gray, who for two generations towered so far above all other leaders of botany in America as to set his work as the standard, both for investigators and teachers. Systematic work involves an extreme attention to terminology and a concentration upon the statical aspects of plant structure. In the hands of poorly trained or overworked teachers it has run much to the filling-out of blanks, collection of herbaria and memorizing of lists of terms, thus becoming educationally little better than a system of mnemonics, or the working-out of mechanical puzzles. This sort of thing is not necessarily bad, but it is woefully uneconomical, one-sided, and neglectful of those other phases of the science that are attractive, useful and illuminating as knowledge, and rich in breadth and sympathy as training.

But these conditions have recently begun to change, and to-day are improving with a rapidity not realized outside of a few centers. The movement is with the expanding science, especially towards the study of the plant alive and in action. Its best evidence is to be found in the most recent elementary text-books, of which a large number, of increasing excellence, have appeared in the past two or three years. A comparison of the works, but a few weeks old, of Barnes or of Atkinson, with the best works of five years ago will show how rapid,

how great and in what direction the change is. Chief of the several causes of the advance is this: University and college teachers, imbued with the newer and broader spirit, are taking an interest in the elementary teaching of their subject not only in their own colleges, but also in the schools. If we consider the elementary text-books of approved standing and widest use in this country that have appeared within the past three years, those by Spalding, Bergen, Strasburger, Vines, Setchell, Curtis, L. H. Bailey, Barnes and Atkinson, we find that with but one exception, they are by university or college teachers. It is, of course, but presumption for any college teacher to attempt to instruct a school teacher in methods of imparting knowledge to school children; but the college teacher, with his broader horizon, larger command of the sources of knowledge, and better facilities for experiment, can best set forth what the science has to offer to education, and the most useful proportioning and treatment of topics. The new school teacher can be trusted to take care of his own methods. This is the spirit of the newer books; they do not seek to impose any system upon teacher or student, but are storehouses of knowledge and advice to be drawn upon by all according to their needs.

We turn next to a summary of advances actually being made in elementary botanical teaching, and of tendencies likely to be of importance in the near future. I need hardly speak of the continuous spread of laboratory and decline of rote instruction; happily this is now a matter of course. Aside from this, the first and greatest of current advances is the shifting of the point of view from the static to the dynamic side of the plant, entailing a great increase of attention to physiology and ecology. We are ceasing to look upon the plant as, first of all, a *structure* to whose parts certain functions attach, and are beginning to see it as a living thing whose functions determine its structure, a working, struggling organism, plastic, though with an hereditary stiffness, to outside influences, not striving to realize some ideal plan, but simply to fit itself to the conditions that exist. Thus the leaf, from one point of view a structure of such a shape, size, venation, cellular composition, etc., carrying on the work of photosynthesis, is from another a mechanism so built as to expose a large amount of green tissue to light and to protect, support, supply and aerate it, and any given leaf is a resultant of the working of all these factors upon it, and as any one of them varies with the external influences so does the leaf vary. Now the clue to this view of the leaf lies in the necessity for light in the formation of starch, the food and sole source of energy of the plant, and this can be appreciated by a student only after experiment upon the relation of light to starch formation, experiment that happily is very easy and everywhere practicable. Thus approached, leaf-structure becomes luminous. In the same way it is absorption of liquids by osmosis that explains the root, and the resultant between the physical requirements of this osmosis and the varying external conditions under which roots are forced to grow, explains why a given root is the form, size and texture it is. Again, it is observation of modes of locomotion of pollen in effecting cross-fertilization, and secondary conditions connected therewith that explain the flower, and so on. Experience is showing that the only road to an objective understanding of anatomy and morphology lies through physiology and ecology. And this conception of the plant, as a living, working, struggling, plastic being is not only the truest, the most objective conception of it, but is, as well, the one that excites the greatest human sympathy and interest, and, therefore, is in itself the best 'method' the science has to offer.

It is sometimes objected that practical difficulties in thus teaching the science are too great to be overcome, for teachers are untrained, experiment is difficult and appliances are expensive. All this is in great measure true, but rapidly coming to be less so, and no one expects, nor is it desirable, that changes should come too rapidly. Many colleges are now training teachers in this knowledge and spirit, and simpler, less expensive and more logically conclusive experiments for demonstrating the fundamental principles of physiology are being invented. There is, however, one difficulty which must be admitted to be very real, namely, the present unorganized state of ecology. At present this division of the science is little better than a series of huge guesses ; very little really conclusive work has been done in it, and no distinct methods of ecological experiment nor principles of ecological evidence have been formulated. Just here lies one of the most attractive fields open to botanists to-day, one whose returns will be of priceless value to botanical teaching.

A second advance is towards a more natural morphology. Next after classification the phase of botany most taught in elementary courses is morphology. But morphology as taught in our schools is dominated by a rigid formalism based on the idealistic system introduced into botany by Goethe, a system easy to teach and one that appeals to a certain stage of culture in both race and individual, but one objectively untrue, and one that, if allowed to dominate and direct morphological conceptions, is actually pernicious and sterilizing. It is only through an approach to structure from its statical or systematic side that one can be satisfied with the conception of plant morphology which views the higher plant as a combination of elements so immutable as to retain their nature through the most extreme changes and combinations, even to the point of being present when invisible, that can find carpel and calyx in all inferior ovaries, can homologize the parts of a stamen with the parts of a green leaf, or ovules with something on the leafy shoot. From this formalism the newer books have broken away ; their morphology conforms to the observed facts of plant development, which show adaptation not to a plan, but to conditions as they have existed.

Among minor advances may be mentioned a wider use of the inductive investigating spirit showing itself in the growing custom of placing new matter before the student in the form of problems so arranged that their solution comes just within the scope of his own powers. Another is a greater flexibility in laboratory methods. The day of published laboratory guides to be put into the hands of students is, I believe, passing; they will be replaced by outlines made by the teacher for each exercise to fit his particular mode of instruction and the material in hand. There is greater nicety and exactness, too, in the laboratory work; the 'rough sketch' is less heard of, and drawings whatever else they may be, must be diagrammatically accurate. Another is a better proportioning of laboratory and text-book work. There is a reaction from the tendency to make laboratory work everything and to scorn the text-book, and the latter, for supplementary reading after the laboratory work, is again in favor, and it is for this purpose the newer and better books are written. All of these advances and tendencies are most healthful and in the line of real advance.

I shall close this subject by pointing out three marked tendencies, not of botany alone, but of education in general, which, in my opinion, are most rich in promise for the advancement of botanical teaching, and which, therefore, all botanists should unite to promote. The first is the tendency to pay less attention to methods and more to

men; to obtain better material for the making of teachers; to educate them thoroughly in the spirit and matter of some one subject or limited group of subjects, and to leave them free to develop their own methods, judging them only by their results. This is what the universities have done with such signal success, what the colleges are now doing and what the schools must do if they are to advance. It is not methods that teach, but men and women. The second is toward the establishment of thorough and continuous courses in Nature Study through all grades from the kindergarten to the high school. There are two reasons for this from our present point of view. Thus only can students acquire a knowledge of the more obvious facts and phenomena of Animal and Plant life, Physical Geography, Physics and Chemistry so valuable as a basis for the systematic study of some one of the sciences in the high school. But, far more important than this is the use of Nature Study to preserve the natural inductive facilities of children unimpaired through school life, not to speak of improving these facuties through training. No fact about our later and better courses of elementary botanical study is more striking than the unanimity with which they begin with exercises adapted to train observation, comparison, etc.—in a word, induction. Now, these are powers that children possess naturally, the most universal of human faculties, those by which new knowledge is won; those by which self-made men succeed; those which surely above everything education ought to cherish and develop. But, as a matter of fact, these faculties somewhere between the primary and high school are so effectually throttled out of nine-tenths of our students that the first need of the high-school or college teacher is to redevelop them. This suppression is, of course, the result of excessive text-book and deductive work, which always tends to make students distrustful of their own powers and leads them to regard as the only real sources of knowledge the thoughts of others properly recorded in printed books. Thorough and properly taught Nature Study is, in my opinion, the first need in all education to-day.

Third of the tendencies I have mentioned is this : The movement among the colleges to require, or at least accept, some one thoroughly-taught science for entrance, amongst which botany is always included. This will compel preparatory schools to improve their teaching, for the science offered must be enough in quantity and quality to allow students to omit the elementary course in the college and enter upon second courses. Moreover, this movement will allow college teachers to exert more influence than ever upon school teaching, for, controlling admission, they can state which topics are to be studied and what general methods are to be followed. A great part of the value to botanical teaching of this movement will, however, be lost, unless, in the very near future, the colleges, through their proper representatives, agree upon approximately-equivalent requirements, so that the preparatory schools may not be distracted and weakened by widely-differing demands.

Though botanists are thus eagerly striving to promote the interests of their science, it is not their desire unduly to magnify its importance, but only to give it its proper place in education and among the sciences. Their aim, I believe, may be thus expressed: Let education advance; let science advance; let botany advance.

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ELEVENTH ANNUAL MEETING OF THE GEOLOGICAL SOCIETY OF AMERICA, DECEMBER 28TH, 29TH AND 30TH, NEW YORK.

I.

The Geological Society of America completed the first year of its second decade with

the eleventh annual meeting at Columbia University, December 28th. Just nine years had elapsed since its last session in New York, which was held at the American Museum of Natural History. The Society assembled this year at 10 a. m., on Wednesday, the 28th, in the large lecture room of Schermerhorn Hall; Professor J. J. Stevenson, the retiring President, in the chair. President Low was introduced and in a few happily chosen remarks welcomed the Society to Columbia. After the usual routine business, President Stevenson read a memorial of the late Professor James Hall, so long State Geologist of New York and the first President of the Society. At the conclusion of the memorial Professor Stevenson delivered his presidential address upon the subject 'Our Society.' He sketched the rise and development of geological organizations in North America and discussed the important influence that they have exercised in the material progress of the country. The address appeared in full in the last number of SCIENCE.

The reading of papers was at once begun, as a list of fifty titles had accumulated.

The Archæan-Potsdam Contact in the Vicinity of Manitou, Colorado. W. O. CROSBY, Boston, Mass.

THE speaker described the remarkably plane character of the contact of the Archæan granite and Potsdam sandstone, which is in striking contrast with the existing topography of the granite even in coastal regions. He distinguished and described in detail, with numerous illustrations, the original and secondary irregularities, the latter including a few flexures and numerous small faults which throw important light upon the origin of the sandstone dikes of the Manitou district. The original irregularities of the contact are all small, and, as a rule, are evidently related to the existence in the Archæan granite of a coarse concentric or spheroidal structure. The plane type of erosion-unconformity, although probably of rather widespread and common occurrence, appears to have attracted less attention than it merits. It suggests interesting possibilities as regards the development of peneplain surfaces in early times and invites a renewed comparison of the relative efficiency in base-leveling of subaerial and marine agencies. These more theoretical aspects of the subject were embraced within the scope of the paper, and the general conclusion was that the Archæan land surface must have passed with extreme slowness beneath the waves of the Potsdam sea.

The paper was illustrated with maps and lantern slides and excited great interest, but did not arouse discussion.

Outline of the Geology of Hudson's Bay and Strait. ROBERT BELL, Ottawa, Canada.

THE author described the general nature of the depression of Hudson's Bay; the contrasted characters of the opposite shores; the Huronian areas on both sides; the Intermediate Formation; the Animikie and Nipigon series; the Trenton group in Hudson's Bay and Strait; the middle Silurian rocks on the east, west and north sides of the Bay and in Baffinland; the large Devonian area southwest of James Bay; the Devonian rocks on Southampton Island; and the geology of the islands in the Bay. He gave a general geological description of Hudson's Strait and of the rocks of its north shore, or southern Baffinland. He also took up the Laurentian and older Cambrian strata of the Ungava district. Under the head of the economic minerals of the regions described, some details of the rich iron-ore deposits, involving carbonates, hematites and magnetites, were presented. In connection with the glacial geology of Hudson's Bay and Strait he sought to show the source of the ice that had yielded the

scratches and its direction of movement. The Quaternary deposits and the question as to the rate of elevation of the land received somewhat extended discussion. The author believes in the recognizable elevation within the historic period and briefly adduced the phenomena on which he based his conclusion.

In discussion B. K. Emerson stated that he was somewhat familiar with the rocks of the region from the collections of the Hall and Kane expeditions which are deposited at Amherst, and from others gathered years ago by English officers. In the latter were fossils of the Utica epoch. J. B. Tyrrell opposed the idea of the recent rise in the west shore of Hudson's Bay, basing his argument upon an old map of the region about Fort Churchill which showed relations like the present ones. David White inquired about the presence of lower Silurian rocks about Frobisher's Bay, and mentioned fossils of the Trenton period which had been identified by Schuchert. H. S. Williams asked if no strata above the Devonian were known. In reply, Dr. Bell again upheld the view that the land was rising and mentioned many arguments in support of it. The Trenton fossils, he said, had come from the northwest in the drift, and that no Carboniferous or later rocks, except Pleistocene, were known.

The Society then adjourned for lunch, and at the afternoon session begun at once the reading and discussion of papers.

The Faunas of the Upper Ordovician in the Lake Champlain Valley. THEODORE G. WHITE, New York City.

THE results of a detailed study of the consecutive faunas contained in each stratum at numerous localities throughout the length of the valley were presented after a preliminary description of the general geology. A complete section is afforded from the base of the Black River formation through the Trenton and terminating in the Utica. Species hitherto reported only from Canadian localities are found associated with those characteristic of the Trenton Falls type-province, showing the Champlain connection with Ordovician seas. Several zones characterized by restricted species are located, and also 'Conglomeratic zones.' The fauna is very abundant and supplies a basis of comparison for similar detailed study from other provinces. The occurrence of the Hudson River and Oneida groups in the region is questioned.

In discussion H. M. Seely spoke of the attractiveness of the region and of its interesting problems and of the need of close paleontological study of the faunas. H. P. Cushing spoke in the same strain, and H. M. Ami remarked the close relationships of the faunas with those of Canada. C. S. Prosser remarked the resemblances and the contrasts with those of the Mohawk Valley.

The Newark System in New York and New Jersey. HENRY B. KÜMMEL, Chicago, Ill.

THE paper presented a general summary of the petrology, stratigraphy and conditions of origin of the Newark rocks in New York and New Jersey. The rocks form a northwestward dipping monocline, interrupted by gentle folds and many faults, two of which have a throw of several thousand feet. The lithological character varies greatly, so that sub-divisions established in one area do not hold for the entire field, and yet sub-divisions based on lithological characteristics are the only ones possible. The author classified them into the Stockton, the Lockatong and the Brunswick formations, together with the traps. Both extrusive and intrusive trap sheets occur and their relations to the sedimentary beds are instructive. The question of thickness is complicated by the faulting. Estimates vary from 12,000 to 15,000 feet. The strata were probably accumulated under estuarine con-

ditions in shallow water. The surrounding land areas seem to have been reduced nearly to base-level and deeply covered with residuary materials immediately preceding the deposition of these beds, but during their deposition subsidence of the estuary and elevation of the surrounding areas was in progress. The paper was illustrated by lantern slides.

In discussion B. K. Emerson brought out many points of resemblance with the Juratrias strata of the Connecticut Valley and N. S. Shaler compared them with those of the Richmond, Va., basin. He argued against their marine origin and in favor of lakes either salt or fresh. A. Heilprin spoke of the fishes which were considered as probably marine by Cope, but N. S. Shaler stated in reply that near Richmond the fish were found in association with vegetable remains. No definite view was reached on this point, although B. K. Emerson remarked that the casts of salt crystals were often seen in the shales in New England. I. C. Russell raised the point of the former extension of the Newark strata of New Jersey to the eastward, but the author had no light to throw on the question. J. E. Wolff and J. F. Kemp discussed the distribution of the boulders from the trap and its contacts over New York City and Long Island.

Discovery of Fossil Fish in the Jurassic of the Black Hills. N. H. DARTON, Washington, D. C.

THE speaker exhibited several specimens of the recently discovered fossil fish and described their occurrence in the Jurassic beds on the confines of the Black Hills. The fish are now being investigated by specialists. The paper was immediately followed by the next one.

Mesozoic Stratigraphy in the Southeastern Black Hills. N. H. DARTON, Washington, D. C.

THE author exhibited a diagram of details of stratigraphy determined in 1898. The investigation resulted in the discovery of marine Jurassic in the southern Black Hills, and of an horizon of large vertebrates in the lower Cretaceous. The paper was beautifully illustrated by lantern slides, and on its conclusion the Society adjourned until the following day.

In the evening the Fellows attended the reception, which was most hospitably extended to the visiting scientific societies by the authorities of the American Museum, and listened with great interest to the addresses of Mr. Morris K. Jesup and Professor Henry F. Osborn. They also attended the reception given by Professor Osborn, at his residence, at the close of the lecture.

On reassembling Thursday morning the reading of papers was at once resumed, the following two contributions being presented together:

Relations of Tertiary Formations in the Western Nebraska Regions. N. H. DARTON, Washington, D. C.

THIS paper presented the results of several seasons' investigations of the White River and the Loup Fork formations, extending from the South Platte River into the Bad Lands of South Dakota.

Shorelines of Tertiary Lakes on the Slopes of the Black Hills. N. H. Darton, Washington, D. C.

DURING the season of 1898 the author discovered extensive and beautiful shorelines and deposits of the Tertiary lakes far up the slopes of the Black Hills. They throw interesting light on certain stages of physiographic development of the Black Hills and the origin and condition of deposition of some of the White River sediments.

No discussion resulted.

General Geology of the Cascade Mountains in Northern Washington. ISRAEL C. RUSSELL, Ann Arbor, Mich.

The region under discussion covers an area from the Northern Pacific Railroad to the Canadian boundary, sixty miles east and west by one hundred and twenty north and south. The following topics were taken up: Terranes—A. *Eruptive*, general absence of basalt, the schists, granites and gneisses, greenstones, andesite of Glacier Peak, volcanic tuff and dust, acid and basic dikes, the source of the Columbia lava. B. *Sedimentary*, *Pretertiary*, *i. e.*, Carboniferous and Triassic strata, including the Similkameen system and the Ventura system. C. *Tertiary* strata, including Snoqualame slate, Winthrop sandstone, Camus sandstone, Swank sandstone, Roslyn sandstone, Ellensburg sandstone. Abundance of fossil leaves. D. *Pleistocene* strata, moraines and valley gravels.

Structural Geology.—Domes, including the Cascade dome, the Wenatchee dome. Folds and faults. *Physiography:* The Cascade peneplain, the Cascade plateau, dissection of the Cascade plateau. Mature topography. Low-grade valleys.

Ancient Glaciers.—On the east side of the Cascades: Yakima glacier, Wenatchee mountain glacier, Icicle glacier, Wenatchee, Chelan, Methow, Okanogan glaciers. On the west side of the Cascades: Sauk glacier, Skagit glacier, confluent ice sheet. Absence of northern drift. Gravel deposits.

Terraces.—Great terraces of the Columbia, the Snake and Spokane, due to climatic changes. No evidence of recent submergence; absence of white silt.

Existing Glaciers of the Wenatchee mountains and the Cascades.

Climate.—The rainy western slope with dense forests and the dryer eastern slope with open forests and grass.

Economic Geology.—Coal, gold, copper, iron, building stone, clays, etc.

In discussion Bailey Willis expressed doubts as to the divisibility of the Tertiary sandstones into so many distinct members, believing that combination would be necessary. He also argued that the domes were due to cross-folding rather than to laccolithic uplift, as urged by Russell. S. F. Emmons suggested lava dams as the cause of the terraces rather than submergence or change of climate. G. M. Dawson said that the white silt was not to be expected in the region under discussion and favored submergence and glacial ice as the causes of the terraces. In reply I. C. Russell stated that the lava flows were older than the terraces, as the terrace gravels were present in cañons cut in the lava. He admitted that Willis's views regarding the sandstones and the uplifts might prove correct and that the causes of the terraces was obscure.

The Society then adjourned for lunch. On reassembling the subject-matter of W J McGee's paper was introduced by W. H. Holmes. Holmes described the discovery of bones and artefacts on the surface in the vicinity of the California gravels that had yielded buried skulls and implements, and detailed the stories of old residents regarding the large part that practical jokes played in the discovery of the remains. He illustrated the geology of the Table Mountain region by sections, and developed the general argument that the relics were those of Digger Indians, who are still in residence,or were within the period of the gold miners. He was followed by W J McGee before discussion opened.

Geology and Archæology of the California Gold Belt. W J McGee, Washington, D. C.

In continuing the paper of Holmes the speaker sketched the geological history of the Western Sierras, emphasizing the Tertiary age of the gravels, the ancient drainage; the inflow of tuffs and lavas; the subsequent erosion of the present steep river cañons to a depth of 2,000 feet. He stated that in this time the fauna and flora had

entirely changed, no species, and, so far as he knew, no genus lasting through to the present except that most variable of all genera, *Homo*, and the species most sensitive of all, to physical changes, *sapiens*. Not only this, but the relics were those of the men, the Digger Indians, living there today, and when not bones the objects were those connected with the acorn industry of the present tribes. From all these considerations a sweeping argument supporting the general improbability of the geological antiquity of the remains was adduced.

In discussion W. H. Brewer spoke of the circumstances under which the discovery of the Calaveras skull was made, he having been at the time on the California Geological Survey. He described its fossilized condition and its contained cemented gravels and stated his belief in its very considerable age even if not Tertiary. He also gave an interesting account of the great theological and ecclesiastical opposition to Professor Whitney that the announcement of the geological age of the skull aroused, amounting almost to persecution. The discovery came shortly after the publication of Darwin's views on the descent of man and in the midst of the excitement that these views aroused.

Major Powell recounted a number of his experiences with discovered relics and the tendency of collectors to palm off modern things as antiquities either in joke or as a fraud. He emphasized the need of depending absolutely on geologists for all reliable testimony as to authentic occurrences in sedimentary deposits. J. A. Holmes spoke in support of the Major's view and related the recently recorded discovery of implements in marl pits and Eocene limestone in North Carolina, the same being attested by affidavits of reputable citizens.

Geology of the Lake Region of Central America. C. WILLARD HAYES, Washington, D. C.

THE speaker discussed the following topics, illustrating his remarks by a fine map. His data had been accumulated while in the service of the Nicaragua Canal Commission and especially from test borings: *Introduction:* general relations of the country under discussion. *Topography:* the coastal plain; the Chontales hills; the Tola hills; the Costa Rican volcanic range; the Nicaraguan volcanic range; the Jinotepe plateau; the lake basin; the Rivas plain. *Climate:* the eastern section of heavy rainfall and dense forests; the western of lighter rainfall and savannahs. *Rock formations:* Tertiary sediments including the older Brito formation and the later Machuca formation; Tertiary igneous rocks, dacites, andesites, basalts, volcanic breccias and conglomerates; recent sediments, alluvium; recent igneous rocks, trachytes, basalts, tuffs and pumice. *The Regolith:* the conditions favor rock decay; the great depth of weathering; red and blue residual clays; concerning weathering in igneous and sedimentary rocks. *Recent geologic history of the region*: early Tertiary deposition; Tertiary erosion; late Tertiary and post-Tertiary uplift and dissection of uplands; recent submergence and alluviation; recent volcanic activity; formation of lakes and shift of divide to westward. *Characteristics of San Juan Valley:* the upperflood-plain; the Castillo-Ochoa gorge; the lower flood-plain.

The paper aroused the liveliest interest from the great importance of the project of the international canal. J. E. Wolff asked about the nature of the rock decay and whether silica, the alkaline bases and iron were removed, leaving beauxite, or whether hydrated silicates resulted. Mr. Hayes replied that he thought the latter, but that no analyses had yet been made of his many samples. Inquiries were raised about the recency of the volcanic outbreaks and the nature of the lava. The reply was that the lava was basalt and the last outbreak about fifteen years ago.

An Unrecognized Process in Glacial Erosion. WILLARD D. JOHNSON, Washington, D. C.

THE glacial topography of mountains was analyzed, and the more distinctive forms discriminated from those of aqueous erosion. The recognized process, that of scour, its action downward and forward with the glacial advance, was described. Glacial scour and aqueous erosion were regarded as alike incompetent to bring about the results and as a rule inimical to the production of known forms. An unrecognized process was set forth, that of sapping, whose action is horizontal and backward. The tendency of glacial scour is to produce sweeping curves and eventually a graded slope. The tendency of the sapping process is to produce benches and cliffs. Sapping is altogether dominant over scour. Under varying conditions, however, its developing forms become obsolescent; their modification, then, by rounding off of angles, puts them seemingly into the category of scour forms. An hypothesis was advanced as to the cause of glacial sapping. The ultimate effect is truncation at the lower level of glacial generation. A second analysis and a more appreciative classification of transition types terminated the paper.

Before discussion the next paper was read because it dealt with allied phenomena. The hour, however, being late, the discussion went over till the next day.

Geology of the Yosemite National Park. H. W. TURNER, Washington, D. C.

BY means of lantern slides the author illustrated the topography of the granite areas in the high Sierras and the Yosemite and other allied gorges. He developed the view that joints had chiefly caused the precipitous cliffs, and concentric shelling off, the domes. Minor forms were also explained. He opposed the view that faulting had caused the gorges.

Gold Mining in the Klondike District. J. B. TYRRELL, Ottawa, Ont.

BY means of a fine series of lantern slides the author illustrated the geographical situation and the geology of the Klondike gold-bearing gravels. The stream gravels are the usual type of placers, but the bench gravels are small lateral moraines left by glaciers. The gold has not been derived from any distance.

The Nashua Valley Glacial Lake. W. O. CROSBY, Boston, Mass.

BY means of lantern slides from photographs and from maps and profiles based on bore-holes made by the officials of the Boston department of municipal water supply, the speaker described the bed-rock surface, the overlying gravels on the Nashua River, and the characters of the old glacial lake of whose former existence they gave evidence.

On the conclusion of the paper, at 5:45 p. m., the Society adjourned until the following day. In the evening about one hundred Fellows, many with their wives, gathered at the Hotel Logerot for the annual dinner. Under the presiding oversight of Professor B. K. Emerson, the past grand master of all the toastmasters, another enjoyable gathering was added to the list of those previously held.

J. F. KEMP.

COLUMBIA UNIVERSITY.

(*To be Concluded.*)

SCIENTIFIC BOOKS.

Theory of Groups of Finite Order. By W. BURNSIDE, M.A., F.R.S., Professor of Mathematics at the Royal Naval College, Greenwich. Cambridge, The University Press. 1897. 8vo. Pp. xvi+388. Price, $3.75.

If, assuming a single but elevated point of view, we describe mathematics as the science of formal law, then the theory of operations easily commands the field, for it is the quintessence of mathematical form, the comparative anatomy,

so to speak, of the mathematical sciences. Originally appearing under the special guise of the theory of substitutions and developed in this form by the labors of Galois, Cauchy, Serret and Jordan with reference chiefly to its application to the theory of equations, it has of more recent years overleaped at once its scientific and its national limitations and, receiving new impulse at the hands of Kronecker and Cayley, has been developed largely by Klein and Lie into one of the chief general instruments of mathematical research. In every branch of mathematics the point of view of the theory of operations is now predominant; it is employed in almost every form of mathematical investigation, and by the reaction the science is in turn constantly enriched. Conspicuous instances are Klein's theory of the modular equations and Lie's theory of differential equations.

The number of separate works devoted wholly or in part to the theory of operations is comparatively very small. Serret's Algebra held the field alone down to the appearance in 1870 of Jordan's classical Traité. Netto's Theory of Substitutions, published in 1882, was the first German book on the subject and represents, as regards its special subject, the German (Kronecker) standpoint down to that date. The American translation (1892) of Netto's book was the first separate work in English to touch the field; in fact, it was almost the first presentation of the subject in any form in English. In 1895–96 appeared the two volumes of Weber's Algebra, a work the value of which as a systematic and modern treatment of the various branches of algebraic science cannot be overstated. To this work, rich in other treasures, belongs the distinction of being the first treatise to present the theory of operations in general form independent of the particular content to which the operation might be applied. Closely following the work of Weber, comes now the second English book on the algebra of operations, Burnside's Theory of Groups of Finite Order. Professor Burnside's work is a doubly welcome contribution to the literature of the subject. It not only opens up to the English reader a great and hitherto almost foreign field, but it presents in a form often original and always valuable the most recent developments in that field, to which the author himself has, in fact, made no insignificant additions. Many portions of the subject, otherwise only to be gathered piecemeal from the journals, are here brought together for the first time in orderly sequence. Proofs have been recast and simplified or extended, and the book contains an abundance of those special details and examples, perhaps too familiar in English mathematical works, but very acceptable here in the midst of a highly abstract theory.

To the reader whose vocation or avocations have not lead him into this remote region of serene thought a short excursion among the groups may be instructive and more or less agreeable. Let him, then, first become familiar with the idea of the 'product' of two operations. This is simply the single operation which alone produces the same effect as the successive performance of the two given operations. If it be asked: "What sort of operations do you mean?" I reply with unction: "Any kind you please, and the more general the conception the better." Algebraic, geometric, physical, chemical, even metaphysical or 'sociological' operations, if nothing better offers, all are taken in one net. But to condescend from this lofty altitude, let us take for an example the rotations of a sphere about its diameters. Choosing any two of them, and applying them successively to the sphere, regarded as a rigid body, the resulting, or *resultant*, displacement of the sphere is equivalent to a third rotation about a proper diameter. This third rotation is, then, the *product* of the two given ones. The rotations of the sphere, taken all together as a system, serve also to exemplify the next important notion, that of a 'group.' When a system of operations is so constituted that the product of any two of them is itself an operation of the system, so that the system is a *closed* one with respect to the process of forming products, then if a couple of minor conditions are also satisfied, the system forms a group. And now the theory of operations in its present form concerns itself not with all kinds of operations, but with these groups. Examples of groups are not far to seek, after the idea is grasped. No science is exempt from them; in mathematics they simply tumble over each other. Transfor-

mations of coordinates in geometry form a group; so do the projections of a plane or of space; the motions of space as a rigid body form the Euclidean group of motions; the $n!$ permutations of n letters form a group; the eight permutations of x_1, x_2, x_3, x_4 which leave the function $x_1 x_2 + x_3 x_4$ unchanged in form, form a group; the multiplication table, the operations of the post office, the theory of the tides, psychological phenomena, all embody characteristic groups. A specially important class of groups, which may serve to close the list, is that of the linear transformations (which are formally identical with geometric projections and with various other operations). Thus the equation

$$z' = \frac{\alpha z + \beta}{\gamma z + \delta}$$

may be looked upon as defining an operation by which any number z is connected into a corresponding number z'. If we have two of these operations, and if, having applied the one to z, getting z' as a result, we apply the other to z', getting z'' as a result, then an examination will show that z'' is itself a linear function of z, *i. e.*, the product of two linear transformations is a linear transformation.

Prepare now for a step into the abstract. In expressing ourselves in terms of 'operations' we have been walking on the crutches of the concrete. But if we designate the operations of a group by A, B, C, . . . , their products AB, BC, . . . have a definite mode of formation, constituting an *algebra*, and we will now throw away the 'operations' and keep the symbols and their algebra. The symbols are now 'elements,' and if these elements form a group the product AB is identified by the algebra with some element C of the same group. Two other properties have to be added to make the definition of a group precise: (1) the algebra must be associative, *i. e.*, $(AB).C = A.(BC)$, and (2) if $AB = AC$ then $B = C$ and if $AB = CB$ then $A = C$. Algebras can, of course, be constructed which omit these conditions, but they are not algebras of groups.

The *order* of a group is the number of its elements. A group may be of finite or infinite order, *e. g.*, all the rotations of a sphere about its diameter form an infinite group; those of them which turn into itself a regular polyhedron inscribed in the sphere form a finite group. Infinite groups are only touched on in Burnside's book. Access to their theory is most readily had through Lie's works. Burnside's opening chapter on abstract groups (Chapter 2) is not so happily executed as Weber's treatment (Vol. II., Chapter 1), which is a masterpiece (*Cf.* also Frobenius's 'Ueber endliche Gruppen,' *Berliner Sitzungsberichte*, 1895, p. 163). Burnside retains the operations and makes use of their concrete qualities in discussing properties which are better treated in the pure abstract.

From the mere definition of a group it is possible to raise a considerable crop of properties without any artificial fertilizer. Add the ideas of isomorphism and transformation, and consider the groups whose elements are commutative (Chapter 3), and those whose orders are powers of single prime numbers (Chapter 4), and the wilderness fairly blooms. Even the non-specialist may rapidly make his way through the easy roads and add valuable ideas to his stock as he goes. He can hardly do better than to read this book, which gives a very clear and straightforward treatment of these general matters. But this is mere surface production. Underneath is gold, but only the Frobenius brand of dynamite will reach that. More than twenty-five years ago a solitary prospector, Sylow, found the lode and worked it with good results as far as he could follow it. Others have tried new leads, but none have accomplished anything remarkable until the work of Frobenius, who in the past ten years or so, and more particularly in his articles published in the *Berliner Sitzungsberichte* for 1895–6 has opened up a vast wealth of new relations, at the same time revising and enriching the earlier methods, nomenclature, and general point of view. Some of the most prominent of Frobenius's results are discussed in Chapter 6. Another line of ideas, which, however, dates back in its beginning as far as Galois, and has been improved especially by Hölder, the theory of composition of a group, is discussed in Chapter 7. The three following chapters are devoted to an extensive discussion of substitution groups, whose theory has also been considerably extended of recent years. The theory of isomor-

phism of a group with itself, also a very recent notion, is given a full chapter. The scene then shifts to the graphical representation of groups, exploited by Klein in his treatment of the automorphic functions, and treated separately by Dyck, whose methods are here employed. Cayley's color groups also receive attention. A chapter follows on the linear group, following Jordan's classical discussion. Finally, Sylow's theorem and its derivatives are applied to the determination of the composition of groups whose order are resolved into prime factors.

The book concludes with a useful trilingual table of equivalent technical terms and a still more useful Index. The publishers have done their full duty; the type is large and clear, and the paper gives a good impression. The text would have been improved by the introduction of descriptive section headings, and frequently the reader is not kept comfortably informed of what the author has in view, and must suspend judgment for a too lengthy interval.

The small public to which such a work appeals makes it unlikely that books on the theory of groups should ever become very numerous. It is fortunate, therefore, that in Professor Burnside's treatise we have a work of genuine and permanent value from which many a future student may draw wholesome inspiration.

F. N. COLE.

Elements of Sanitary Engineering. By MANSFIELD MERRIMAN. John Wiley & Sons. 1898.

The book opens with an interesting and, for a student, instructive series of historical notes. This is followed by a section dealing with 'classification of disease,' wherein may be found the novel proposition that 'disease is normal and health ideal—' a view that will call forth much opposition.

The illustrations distinguishing between contagion and infection are good, but the suggestion that goitre is probably due to the use of limestone water is hardly warranted; for, were it a fact, the hard waters of southern England should produce the disease abundantly.

An excellent and timely statement is given in the table on page 17, showing how much more serious is consumption than sundry other diseases against which we take far greater pains to guard.

The relation of filth to disease is well put, and the illustrations are striking. The chapter on 'drinking water and disease' is in terse form, suitable for class-room work, but the remarks concerning the Hamburg cholera epidemic need to be supplemented by a map of the city, in order to grasp fully what may be learned from that instructive outbreak.

The book is evidently intended for use as a student's text-book, and excellent questions are inserted at frequent intervals, which require the student to make use of a reference library. This is a very valuable feature, and one but rarely found. There is, unfortunately, no index.

M.

Bush Fruits: A Horticultural Monograph of Raspberries, Blackberries, Dewberries, Currants, Gooseberries and other Shrub-like Fruits. By FRED. W. CARD, Professor of Horticulture, Rhode Island College of Agriculture. The Macmillan Company. 1898. Pp. xii + 537. Price, $1.50.

Under this concise and somewhat descriptive title another book is added to the list upon small fruits, from which, in this instance, are excluded the grapes, strawberries and cranberries.

The contents are divided into three parts, namely, (I.) General Considerations, (II.) The Brambles and (III.) The Groselles. The last name is adopted from the French, includes both the currants and gooseberries, and is a convenient term as a heading for a book division, but will scarcely be of much service elsewhere.

Under brambles, of course, the red raspberries, black raspberries, blackberries and dewberries are considered each with its separate chapter.

Part I. deals with the consideration of location, fertilizers, planting, tillage tools, pruning, propagation, thinning, spraying, picking, packing and marketing of fruit, with a few closing pages upon the methods of crossing and the results of such blending of the varieties and species.

Many of the above-mentioned points are again more specifically treated under the chap-

ters devoted to the separate groups of bush fruits, and the whole book is so planned that the practical grower may quickly reach replies to the questions in hand by means of a full index even to the varieties of each sort of fruit embraced by the work.

The more scientific portions of the volume are kept as far as possible by themselves, set in smaller type and include histories of the various sorts of fruits, their insect enemies and fungous diseases. This separation is a wise provision for the convenience of the grower, for whom the book is especially written and who is more interested in the art of producing a profitable crop than the underlying principles of botany upon which the art securely rests. For example, there are nearly fifty pages of descriptive text of species of Ribes set under the chapter title of 'The Botany of the Groselles,' and many of the species are figured. Such portions of the work as this are of much value to all who desire to advance American horticulture by introducing new species to cultivation or extending the range of hybridization.

In the more practical part it may be noted that special stress is placed upon the evaporation of the fruit, and several illustrations are given of the apparatus employed in this growing industry. In the preface, by the editor of 'The Rural Science Series,' of which the 'Bush Fruits' is the sixth volume, Professor Bailey states that 'the aim has been to treat general truths and principles rather than mere details of practice.'

The book is written by one who has both an experience with bush fruits and a knowledge of the best things that have been thought and said along the lines he has followed out to a successful issue in the volume in hand.

BYRON D. HALSTED.

The Lower Cretaceous Gryphæas of the Texas Region. By ROBERT THOMAS HILL and THOMAS WAYLAND VAUGHAN. Bulletin of the United States Geological Survey, No. 151. Washington, Government Printing Office. 1898. Pp. 66. Pl. xxxv.

The main object of the authors in publishing this brochure is to set aright the confusion that has long existed regarding the classification and stratigraphic position of a series of fossil oysters commonly assigned to a single species, *Gryphæa pitcheri*, Morton. They occur in especial abundance in the Lower Cretaceous formations of Texas, and when properly classified are found to be of great value in determining the position of strata. From forms heretofore known as *G. pitcheri* at least eight species are here recognized (Table, pp. 45–46), viz.. *G. vesicularis*, Lam., 1806; *G. newberryi*, Stanton, 1893; *G. mucronata*, Gabb, 1869; *G. washitaensis*, Hill, 1889; *G. navia*, Hall, 1856; *G. corrugata*, Say, 1823; *G. marcoui*, Hill and Vaughan, 1898; *G. wardi*, H & V, 1898. It is found, furthermore, that even Morton's species (so long considered the type) must be abandoned in favor of Say's *G. corrugata*.

The introduction, dealing historically with the controversy of many years' duration concerning *G. pitcheri* and the formations in which it occurs, is not without a moral, inasmuch as it plainly shows that an inadequate description, with a poor figure, may become a fruitful source of error, which, as in the case of the species under consideration, may be greatly augmented by the want of proper stratigraphical knowledge on the part of collectors.

An account of the fossil oysters of the Texas region and a classification of the Ostreidæ follows. The difficulties encountered by the authors are not underestimated: "In undertaking the study of the Ostreidæ one is soon confronted with the question: What constitutes species and genera in this group? The variation of species is much greater in the Ostreidæ than in other molluscan genera. No other group presents such unsatisfactory criteria for specific differentiation. These forms, judging from their stratigraphic occurrence as well as their habits, seem to adopt new variations of shape with every change in physical condition of habitat, as is illustrated in the variations of our living species. Changes similar to those occurring at the present time have occurred in the past, and no doubt many species have arisen by some of these local variations becoming fixed and persistent. Large suites of specimens often show that two species usually considered very distinct may grade into each other. The intergradations are of such a kind that frequently it can easily

be shown that the two species have been derived from a common ancestor; in other cases one species is evidently derived from another occurring stratigraphically below it."

Contrary to the prevailing opinion that fossil oysters, on account of their great variation, are of little value in the recognition of strata, our authors are led by their observations to conclude "that certain forms of the Ostreidæ possess very distinct specific characters, have definite geologic horizons, and are of the greatest value in stratigraphic work." They recognize the fact, also, that no scheme of classification can be entirely satisfactory until both fossil and recent oysters have been "the subject of thorough investigation from a phylogenetic and morphologic standpoint, according to the lines of research followed out by Hyatt in the cephalopods, Jackson in the pelecypods, Beecher and Schuchert in the brachiopods and Von Koch in the stony corals."

Sixty-one accepted species and varieties of fossil oysters are listed as occurring in the Texas Cretaceous, and twenty-three indefinite and abandoned species. Of the former forty-seven are tabulated as characteristic of definite horizons (p. 31).

Under the caption 'Historical Statement of the Discovery in the Texan Region of the Forms referred to *Gryphæa pitcheri*, Morton,' the confusion of various authors concerning this famous fossil is clearly presented and the sources of error pointed out. The following topics of more than ordinary interest are also discussed: 'Differentiation,' 'Geographic and Stratigraphic Distribution of the Lower Cretaceous Gryphæas,' 'Specific Classification and Evolution of the Lower Cretaceous Gryphæas,' and the bulletin closes with careful descriptions of six species, characteristic of the Lower Cretaceous, which the authors believe to merit recognition, supplemented by a brief statement of their relationship. The excellent and copious illustrations which accompany this paper deserve especial commendation. Of thirty-five plates, thirty, including copies of figures from Hall, Marcou and Roemer, are devoted to Gryphæas; of the remainder, one is a view of a living oyster bed, showing the profusion of molluscan growth, the others sections showing the stratigraphic occurrence of the Texas Cretaceous Ostreidæ.

FREDERIC W. SIMONDS.
UNIVERSITY OF TEXAS.

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Elements of Graphic Statics. PROFESSOR L. M. HOSKINS. New York and London, The Macmillan Company. 1899. Pp. viii+199, and eight plates. $2.25.

SCIENTIFIC JOURNALS AND ARTICLES.

THE *American Naturalist* for January opens with an article by Dr. Arthur Hollick discussing the relation between forestry and geology in New Jersey. Professor W. M. Wheeler gives a biographical sketch of the late George Baur, which is accompanied by a biographical sketch containing 144 titles. Articles follow by Miss Julia B. Platt, describing certain phenomena of geotaxis; by Professor Cockerell, on 'Vernal Phenomena in the Arid Regions,' and by Professor E. W. MacBride, reviewing Seitaro Goto's work on the development of *Asterias pallida*.

THE *American Geologist* for January opens its twenty-third volume with a notice of Edward Drinker Cope, by Miss Helen Dean King, with a portrait and a bibliography containing 815 titles. There follow articles by Dr. N. H. Winchell, on 'Thalite and Bolingite from the North Shore of Lake Superior,' and by Mr. Marsden Monson, on 'The Loss of Climatic Evolution.'

THE *Journal* of the Boston Society of the Medical Sciences for December, 1898, contains an abstract of an interesting paper by Dr. Morton Prince entitled 'An Experimental Study of Visions,' also an important paper by Dr. Franklin W. White upon 'the Germicidal Properties of Blood Serum.' Among the conclusions reached are these: Human blood serum differs greatly in its germicidal action

upon various bacteria; in fatal diseases it sometimes loses part of its germicidal power for the colon bacillus shortly before death, but more frequently retains this power for several hours after death; human blood serum does not lose its germicidal power for typhoid and colon bacilli, even in the late stages of chronic wasting disease.

THE *Philadelphia Medical Journal*, which during its first year has secured a high position among medical journals, will hereafter publish a monthly supplement of 60 pages containing original articles.

SOCIETIES AND ACADEMIES.

NATIONAL GEOGRAPHIC SOCIETY, JANUARY 6, 1899.

Abstract.

'THE Work of Glaciers in High Mountains:' By Willard D. Johnson. The greater number of the imposing forms in the summit regions of nearly all high mountains are of unknown origin. They are, however, strictly confined to tracts which either have in the recent past been glaciated or are glaciated now. Presumably, therefore, they are of glacial origin. But the difficulty is that, according to the known laws of glacial erosion, they are unintelligible.

The recognized process in glacial erosion is scour. This process, like aqueous corrasion, must always tend—in uniformly resistant and unfractured material—to produce graded slopes. But in glaciated summit regions, especially in granite and in tracts of that rock which answer most nearly to ideal conditions of uniform hardness, the topography is essentially that of flat valley floors and of upright cliffs, transverse as well as longitudinal to the direction of flow. In sound rock both glacial scour and aqueous corrasion will be not only incompetent but inimical to the production of such forms.

An unrecognized process appears to be that of sapping. The transverse, and therefore buried, cliffs in the glacier's pathway, as well as the amphitheatral cliff at its head, are cliffs of recession. The action of scour is downward and outward with the glacial advance, but the action of sapping is horizontal and backward. It is seldom lateral, and then only for a brief space. The flat valley bottom, as well as the parallel valley walls (where subsequent scour has not dulled their upright profiles), are by-products of recession of the transverse cliff.

So long as, along any advancing line, it continues active, sapping will be altogether dominant over scour, accomplishing large results in excavation; but its action, apparently, is by successive attacks, from point to point, and has relatively brief duration. Its forms, thereafter, arrested in development, become obsolescent under the contiuous action of scour, and the rounding-off of angles puts them seemingly into the category of scour forms.

The following hypothesis is advanced as to the cause of glacial sapping: The glacier protects its bed against the sharp variations of temperature which, by mechanical disintegration, waste exposed slopes. At the same time the covered rock surface is maintained close to zero, Centigrade—a critical temperature. By tearing away at its head from the mountain slope, and by reason of initial irregularities of bed along its line of flow, the glacier is broken across. If the depth of ice be not too great these breaks, or crevasses, will penetrate to the bottom. Along the narrow transverse line of bed, or floor, thus exposed—during summer, while the crevasse is open—there will be oscillations of temperature, between day and night perhaps, accomplishing an alternation of freezing and thawing. This alternation across the freezing point, at the crevasse foot, will be much more frequent than upon the exposed slopes without—a diurnal, rather than a seasonal, change. The crevasse foot will thus be a line of sharply localized and abnormally vigorous weathering, by coarse mechanical disintegration. The glacier is an agent here, directly, only in the removal of waste products. Frost-fracturing acts vertically downward, as well as horizontally backward, into the cliff, which it thus undercuts; but the products of its downward work are much less readily removed, and failure to remove operates to defeat downward action. Thus the cliff recedes, leaving in its trail an approximately flat and horizontal floor. In the slight unevennesses of this floor, after glacial conditions have passed and the cañon has become emptied, rock-basin lakes accumulate.

By recession at the amphitheatre head—and the glacier makes the amphitheatre, rather than merely occupies it—the amphitheatral wall is carried backward, and divides are cut through. A summit region, upon either slope of which glacial streams are extended, will be trenched by streams heading thus in opposition. A first effect of the meeting of an opposing pair will be the arête, or thin comb—the most evanescent of mountain forms; the final effect will be the col—a low-level pass between walls. The ultimate result of continued glaciation must be truncation of the crest region, close to the lower level of the glacial generation. Transitional forms will be not only the arête and the col, but the aiguille, or minaret, the residual table, the cañon of diverted discharge, the cañon of Yosemite type, and the towering peak of Matterhorn type, against which divergent streams will burrow at their heads, scalloping its base, and maintaining its sinking summit as the sharp apex of a slender and fluted pyramid.

HARVARD UNIVERSITY: STUDENTS' GEOLOGICAL CLUB, DECEMBER 19, 1898.

UNDER the general title, 'Geological Results of the Recent Storm upon the Massachusetts Coast,' five members reported observations. Mr. R. B. Earle described results noted on the Winthrop and Beachmont shores. Winthrop Beach, usually sandy and of gentle slope, bore a series of gravel cusps, terminated on the seaward side by spits that pointed toward the southeast. Whenever these cusps were composed of coarse gravel they were high and near together; when of fine material they were low and far apart. In the Beachmont Bluff, at similar intervals, was a series of cavern-like undercuttings. A portion of the beach, below the Bluff, was covered with heaps of seaweed shaped into cuspate forms, but another portion was degraded to a depth of three feet.

Mr. A. W. G. Wilson visited the south shore from Windmill Point to Cohasset Harbor. At the former locality sand and gravel were thrown inland thirty feet. The railroad track that ran close to high-tide level, along the front of the drumlin upon which the town of Hull is located, was protected by a breakwater of granite and diorite blocks. From this breakwater, some blocks, which weigh approximately a ton or more, were moved back ten feet and raised between one and two feet. Nantasket Beach, in front of Strawberry Hill, was cut down four feet, and back in places twenty feet, for a distance along the beach of five hundred yards. Sections of sewer pipe thus revealed afforded a basis for measurement. At the southern end of Nantasket, where most of the wrecks were washed up, large quantities of *thoroughly rounded*, soft coal were imbedded in the beach sand to a depth of at least ten inches. A short distance east of Gun Rock, half a mile from Nantasket, some houses stand one hundred yards inland and from six to ten feet above normal high water level. Coarse gravel accumulated against these houses in heaps three feet high and buried a neighboring road between two and three feet deep. At Hull and in the region of Gun Rock, where a salt marsh and a pond, respectively, lay back of the beach, new, storm-built beaches have encroached upon the marsh and pond, in the form of well-marked series of gravel spits from one to five feet in height.

Mr. J. M. Boutwell offered three records of height of water. At Lynn Beach the position of pebbles and débris indicates the submergence of its Nahant end. At its Lynn end, according to the statement of an eye witness, the water rose over the road to a depth of three feet and swept completely across the beach. At Milton, in the Neponset River, a rod has been so placed that its top marks the height reached by the high tide of 1851. One eye witness states that during the recent storm the water rose to within three inches of the top of this rod; another affirms that he saw it rise over the top. At the Boston end of the West Boston bridge the water in the Charles River rose to within one inch of the street level. The tide predicted for November 27th was the normal high-tide, ten feet two inches at Boston. Had the storm passed at the time of spring-tide, about two days later, the water would have risen fully a foot higher. As it was, the concomitant effect of an imminent spring-tide, a strong, low pressure area and an onshore wind was to raise the water higher, at some points, than it was during the high tide of 1851.

J. M. BOUTWELL,
Chairman.

ONONDAGA ACADEMY OF SCIENCE.

AT the November meeting of the Academy Professor P. F. Schneider read a paper on 'Onondaga Whetstones,' giving a short history of the use of whetstones and comparing the various commercial stones. The Labrador stone is found at the southern border of the county and is manufactured in a nearby town. It makes an excellent 'table stone.' The Arkansas stone is also manufactured by the same company, the 60,000 pounds annually shipped here yielding about 20,000 pounds of the finished product.

At the December meeting of the Academy Professor Schneider spoke on 'Palæobotany of Onondaga County,' illustrating his remarks by about a dozen plant remains from the local Silurian and Devonian rocks.

Mrs. L. L. Goodrich spoke on 'Variations in *Trilliums*,' and exhibited specimens ranging from the typical *Trillium grandiflorum* through gradations of petioled leaved forms to extreme forms with purely radical leaves. In nearly all cases the petals were more or less marked with green, and various degrees of reduplication and suppression of floral parts were noted as common occurrences.

Dr. A. A. Tyler spoke on 'The Origin of Species Through Variations,' after which the topics of the evening were discussed by Dr. W. M. Beauchamp and Dr. Hargitt.

H. W. BRITCHER,
Corresponding Secretary.

THE ACADEMY OF SCIENCE OF ST. LOUIS.

AT the meeting of the Academy of Science of St. Louis, of January 9, 1899, the following officers were declared elected for the current year: President, Edmund A. Engler; Vice-Presidents, Robert Moore, D. S. H. Smith; Recording Secretary, William Trelease; Corresponding Secretary, Joseph Grindon; Treasurer, Enno Sander; Librarian, G. Hambach; Curators, G. Hambach, Julius Hurter, Hermann von Schrenk; Directors, M. H. Post, Amand Ravold.

Mr. Hermann von Schrenk presented informally the results of a study of a sclerotium disease of beech roots which he had observed in southeastern New York during the past summer. The sclerotia, which were formed by the webbing together of rootlets by sterile mycelial threads, were stated by the speaker to have apparently no connection with the mycorrhiza of the beech. Mr. von Schrenck's remarks were illustrated by drawings and alcoholic and sectioned specimens.

WILLIAM TRELEASE,
Recording Secretary.

DISCUSSION AND CORRESPONDENCE.

SCIENCE AND POLITICS.

AT the last biennial session of the Legislature of Kansas there was passed what is known as the State uniform text-book law. A commission was appointed whose duty it was to select the text-books of all grades used in the public schools of the State, which were to be furnished at a stipulated price to all pupils. No other texts than the one selected may be used by any school under pain of severe penalties. The law has now been in force for two years and these books are being used by several hundred thousand pupils. So far as I can learn, specialists or experts were not consulted in the choice of the texts. Wide latitude was given to the commission, the one important stipulation being that the books should be cheap! Protests have been made, but in vain—the books must be used in every case where prior contracts are not in force. Let us examine the wisdom of the Kansas Solons in one case; I am told that others are like it.

The text in Physiology used in all grammar grades is one by a C. L. Hoxie, whoever he may be. As he is the author of text-books in Physics, doubtless his name will be familiar to the physicists of the country! The work had the benefit of revision by two high-school teachers of St. Louis. The part they took in the revision ought certainly to elevate them from obscurity.

We can sympathize strongly in the introductory statement by the author that the "value of a thorough knowledge of physiology in all of its departments can scarcely be estimated. If one be well a knowledge of physiology will keep him so. If one be sick the same knowledge will enable him to regain that priceless treasure—good health." One must suspect

that the author is a confirmed invalid! His definition of physiology is certainly unique:

"Physiology proper naturally divides itself into three departments, Anatomy, Physiology and Hygiene." "Bones, like all other organic structures, consist of cells; the cells are more or less of a hexagonal form." He seems especially hazy about the lymphatic system: "The lymphatics perform the office of absorption, chiefly in the skin." At one time he has the lymph 'poured into the blood through the thoracic duct into the *vana cava* in the neck,' but farther on he modifies this by saying that the lacteals 'terminate in two ducts, which open into the large veins, and finally into the heart,' one on the right side and the other on the left side of the chest! "The liver performs the double office of separating impurities from the blood and secreting bile." The 'bile acts as a solvent of the fatty portions of food,' while we are informed that 'fat is an oily concrete substance, composed of stearine and elaine!' One of the chief functions of the saliva is to 'quench thirst,' and the 'epiglottis serves to deaden sound!' Among other 'important facts' the author says that the 'heart of quadrupeds lies in the middle line, and not to the left, as in man.' "All reptiles have two auricles and one ventricle." From the fact 'that coagulation is greater in the lower animals' he derives the very interesting conclusion that 'this seems to be a wise provision, since these animals can not stop a flow of blood from a wound by artificial means.'

But enough. These few examples are chosen almost at random. The book contains more poor English, wild and loose statements of fact, errors and absurdities than I ever saw before in a text-book of modern times. One might be amused at such stuff, published as 'science' were it not that tens of thousands of children in this State are compelled to learn it, usually taught by teachers whose ignorance of the subject is greater than that shown by the author himself.

Everywhere that a moral can be lugged in by the ears or tail the baneful effects of the poison alcohol are urged. Can such a book be expected to serve any useful purpose in teaching the principles of temperance?

And this is what politics may do for science in the public schools!

S. W. WILLISTON.
UNIVERSITY OF KANSAS, LAWRENCE.

THE STORING OF PAMPHLETS.

ON reading Professor Minot's explanation of his method of storing pamphlets as given in the issue of December 30th I feel inclined to add a word in commendation of the method. I began using these boxes six or seven years ago and now have 152 upon my shelves. About one-half are devoted to Experiment Station bulletins, the boxes being labeled by States and arranged alphabetically. The other half is used for miscellaneous pamphlets on subjects pertaining to my line of work. The boxes have proved perfectly satisfactory in every way, and as a simple time-saving device they are worth many times the cost. My system of pamphlet arrangement differs in some ways from that adopted by Professor Minot and has been adopted only after trial of several other methods.

Each case is labeled and is also given a number. The pamphlets are numbered consecutively and arranged in the cases, as far as possible, by subjects, and each one is stamped with the number of the case in which it belongs. The location of each is, therefore, permanent. It is always returned to the same case and the same relative position as regards others in the case.

In a convenient drawer of my desk is a card index where all papers are recorded by author and by title. Each card carries the pamphlet number and the case number, thus indicating the exact location of the pamphlet desired. Often a dozen or more pamphlets may be in use, scattered over my work table for several days; when ready to be returned, the numbers direct to the case and to the correct position within the case. If each pamphlet contained but a single article the alphabetical arrangement would be the most simple; but many contain more than one title, often several, and not infrequently by different authors. These were a sourse of annoyance until the present system was adopted. I do not find the system cumbersome, and the time employed in keep-

ing it up is saved many times over by the facility with which reference is made.

CHARLES S. CRANDALL.

THE STATE AGRICULTURAL COLLEGE,
FORT COLLINS, COLORADO.

ZONE TEMPERATURES.

MY attention has been recently called by Dr. Walter H. Evans, of the United States Department of Agriculture, to an error in the temperature tables accompanying my paper on the 'Laws of Temperature Control of the Geographic Distribution of Animals and Plants,' an abstract of which was printed in my recent bulletin on 'Life Zones and Crop Zones.' The error in question relates to the effective temperature or 'sum of normal mean daily temperature above 6° C.' In the tables bearing the above heading the quantities actually given are the sums of normal mean daily temperatures (*without deducting* the 6° C. each day) for the period during which the mean daily temperature exceeds 6°C.

The temperature data, as stated on the first page of my original paper, were furnished by the Weather Bureau. Not being of a mathematical turn of mind, I did not detect the error until my attention was called to it by Dr. Evans. Corrected tables will be given in the next edition of 'Life Zones and Crop Zones.'

C. HART MERRIAM.

PHYSICAL NOTES.

DR. OLIVER LODGE, in a recent paper before the Institution of Electrical Engineers, speaks of the probable importance of leakage currents in the usual methods of telegraphing by magnetic inductance through space. This form of wireless telegraphy has usually been accomplished with long parallel wires on poles and ground returns. In some experiments made by Stephenson near Edinburgh horizontal coils of wire were used and signals transmitted half a mile with a morse key in one coil and a telephone receiver in the other. Mr. Lodge used similar coils covering areas of about 4,500 square yards and transmitted signals about two miles. The characteristics of his method are the use of an alternating current of a rather high frequency, about 380, and the tuning of the line to this frequency by the use of condensers, that is, the balancing of the inductance so that the current becomes equal to the induced E. M. F. divided by the ohmic resistance. As a result, he gets much greater effects than where the current is principally determined by the inductance of the circuits. This he shows by mathematical determination will be the case, the value of $2\pi x$ the frequency, coming in one instance in the denominator, while in the other it comes in the numerator of the expression giving the ratio between the secondary current and the impressed primary E. M. F.

F. C. C.

CURRENT NOTES ON METEOROLOGY.

THE WINDWARD ISLANDS HURRICANE OF SEPTEMBER, 1898.

THE practical advantages gained by the establishment of the new West Indian Service of our Weather Bureau are forcibly illustrated in the account of the hurricane of September 10th and 11th last, published in the September number of the *Monthly Weather Review*. The Weather Bureau Observer at Bridgetown, Barbados, sent a special cable to Washington at 12:40 p. m., September 10th, announcing the approach of a hurricane. Warnings were immediately cabled to Weather Bureau stations in the Lesser Antilles, and the officials in charge were directed to give the widest possible distribution to the warnings. Advisory messages were sent to other islands, as far west as Jamaica and eastern Cuba, to points on the South American coast of the Caribbean Sea, and to Admiral Watson's fleet, lying in the harbor of Caimanera, Cuba. The careful reports of the Weather Bureau Observers at Kingston, Jamaica, at St. Kitts and other stations also made possible an early and complete record of the hurricane.

In this connection another paper, in the same number of the *Review*, is of interest. It concerns the telegraph service of the Weather Bureau with the West Indies, and is illustrated by a chart showing the routes of the submarine cables over which reports are transmitted and the points at which the cables connect with the land lines.

At the December meeting of the Royal Meteorological Society (London) Captain A. Carpenter, R. N., gave an account of this disastrous hurricane.

Its diameter was 80 miles as it approached Barbados, and 170 miles after leaving St. Vincent. The actual storm center, in which the force of the wind greatly increased, was only 35 miles in diameter until St. Vincent was passed, but after that the strength of the wind extended to 170 miles from the center. The diameter of the calm vortex was not less than four miles. The storm was accompanied by very heavy rainfall, the amount at St. Vincent being about 14 inches in 24 hours. In Barbados 11,400 houses were swept away or blown down and 115 lives were lost, and in St. Vincent 6,000 houses were blown down or damaged beyond repair, and 200 lives were lost.

PROBABLE STATE OF SKY ALONG THE PATH OF THE ECLIPSE, MAY 28, 1900.

PROFESSOR F. H. BIGELOW, in the *Monthly Weather Review* for September, considers the probable state of the sky along the path of the total eclipse of the sun, May 28, 1900. His conclusion is as follows: "It would be much safer for the eclipse expeditions to locate their stations in the northern portions of Georgia and Alabama, upon the southern end of the Appalachian Mountains, where the track crosses elevated areas, than nearer the coast line in either direction northeastward toward the Atlantic coast, or southwestward toward the Gulf coast; on the coast itself the weather is more unfavorable than in any other portion of the track." Professor Bigelow's paper is illustrated by means of a chart.

NOTES.

THE November number of *Climate and Crops, Illinois Section*, in commenting upon the statistics of losses by lightning in Illinois during 1898, says: "A survey of the reports shows a very marked increase in the loss of stock due to the wire fence, and the urgent need of frequent ground wires in those in use." (See note in this connection in SCIENCE, Dec. 2, 1898, p. 785.)

R. DEC. WARD.

HARVARD UNIVERSITY.

CURRENT NOTES ON ANTHROPOLOGY.

THE OLDEST SKULL-FORM IN EUROPE.

IN the *Centralblatt für Anthropologie* (Heft. 4, 1898) are some abstracts touching the skull-form which is believed to be the oldest in Europe. It is represented most perfectly by the remains found at Spy. The characteristics are: uncommon length, moderate width, very limited height, retreating forehead, prominent but depressed supra-orbital ridges and narrowed post-orbital diameter. Dr. Fraipont argues sharply for the genuine ancient character of the Neanderthall skull, and Dr. Schwalbe does not regard that found at Egisheim as a good type. As for modern examples simulating the Neanderthal skull the latter asserts that, while they may resemble it in one or another point, they never present the group of inferior criteria which characterize its measurements.

THE SUPPOSED 'OTTER TRAP.'

DR. ROBERT MUNRO in his excellent work, *Prehistoric Problems*, has a chapter on a curious object found in the peat bogs of Europe, from Italy to Scotland and North Germany. He has recently supplemented that chapter by an article describing further examples. (*Jour. Roy. Soc. Antiquaries of Ireland*, September, 1898.)

The object is a thick board or plank, two to three feet long, in the center of which is an oblong aperture four to six inches wide, closed by one or two valvular doors. The purpose of this arrangement is obscure Dr. Munro argues that it is an otter or beaver trap, while others have explained it as a boat-model, a sluice-box, a float for lines, etc.

The suggestion which I would offer for its use differs from any I have seen. It is doubtful that the valves could hold firmly an otter or any such animal. The purpose for which it would be entirely suited would be that of the inlet to a fish-weir. The valves, opening inward, would allow the fish to enter and would prevent their exit. Similar, though not identical, devices are in common use.

ANTHROPOLOGICAL STUDY OF FEEBLE-MINDED CHILDREN.

IN a supplement of the 48th annual report of the managers of the Syracuse State Institution for feeble-minded Children, Dr. Alex. Hrdlicka presents an anthropological study of a long series of these unfortunates. It includes their family conditions, the supposed etiolog-

ical factors of the deficiency, and the physical examination of the subjects.

While the report is very instructive on many individual features, it admits of few general conclusions other than that we need much more extended investigations than have heretofore been prosecuted, in order to reach positive opinions as to the causation and the status of the feeble-minded; and this is Dr. Hrdlicka's own decision (p. 95).

D. G. BRINTON.

UNIVERSITY OF PENNSYLVANIA.

SCIENTIFIC NOTES AND NEWS.

M. VAN TIEGHEM, the eminent botanist, succeeds M. Wolf as President of the Paris Academy of Science, while M. Lévy has been elected Vice-President.

AT its meeting on January 11th the American Academy of Arts and Sciences elected Charles Doolittle Walcott, of Washington, an Associate Fellow in place of the late Professor James Hall, and Oliver Heaviside, of Newton Abbot, England, a Foreign Honorary Member.

IT is proposed to erect a monument in memory of Fèlix Tisserand, Member of the Institute of France, and of the Bureau of Longitude, and Director of the Observatory of Paris, at Nuits Saint-Georges (Côte-d'Or), his native place. Subscriptions will be received at Nuits-Saint-Georges, by M. Desmazures, Receveur Municipal; at the Observatory of Paris, by M. Fraissinet, and at Dijon, by M. Ragot (rue Colson).

SURGEON-GENERAL STERNBERG is at present in Cuba inspecting the hospitals and arranging for a new yellow fever hospital and a depot for medical supplies in Havana.

THE Permanent Secretary of the American Association for the Advancement of Science, Dr. L. O. Howard, would be glad to learn of the address of José de Riviera, who was elected a life member of the Association at the Boston meeting of 1880.

THE Chemical Society of Washington, at the annual meeting held on Thursday, January 12, 1899, elected the following officers for the ensuing year: President, Dr. H. N. Stokes; Vice-Presidents, Dr. P. Fireman, Dr. H. C. Bolton; Secretary, Mr. William H. Krug; Treasurer, Mr. W. P. Cutter; Executive Committee, the above officers and Dr. C. E. Munroe, Dr. E. A. de Schweinitz, Mr. Wirt Tassin and Dr. F. W. Hillebrand, *ex-officio*.

PROFESSORS VON KUPFER, of Munich; F. Klein, of Göttingen, and E. Fischer, of Berlin, have been made members of the Bavarian Maximilian Order of Science and Art.

PROFESSOR M. E. COOLEY, of the engineering department of the University of Michigan, who has been Chief Engineer on the United States auxiliary steamer Yosemite since the outbreak of the Spanish-American war, will return to the University in time to begin work with the second semester. He was detached from the Yosemite December 23d, since which date he has been doing temporary work at the League Island Navy Yard. He expects to be relieved from duty by the first of next month.

MR. WM. T. HORNADAY, Director of the New York Zoological Park, has been elected a corresponding member of the London Zoological Society.

Nature states that Mr. Frederick G. Jackson, the leader of the Jackson-Harmsworth expedition, has been presented with a first class of the Royal Order of St. Olaf by King Oscar of Sweden and Norway.

THE Paris Academy of Sciences has nominated for the chair of chemistry in the Conservatoire des Arts et Métiers as first choice M. Florent, and as second choice M. Joannis.

MR. JOHN BARROW, F.R.S., the author of works on travel and physiography, has died at the advanced age of 91 years.

PROFESSOR JOSEPH BALDWIN, who held the chair of pedagogy in the University of Texas, died on January 14th, aged 70 years.

AT the annual meeting of the Indiana Academy of Science held at Indianapolis during Christmas week, Mr. W. W. Woollen announced that he had set aside forty-four acres of land situated nine miles from the center of Indianapolis, for a garden of birds and botany. He proposes to develop the garden and present it to the city of Indianapolis, to be placed under the control of the Superintendent of Schools, the President of Butler College, and the President

of the Academy of Science, for the use of the bodies represented by them.

THE Association for maintaining the American women's table at the zoological station at Naples announces that it is prepared to receive applications for use of the table, which should be addressed to the Secretary, Miss Ida H. Hyde, 1 Berkeley St., Cambridge. The Executive Board has at its disposal a small fund for the aid of scholars of the Association who may need assistance to meet the expenses of travel and of residence in Naples. The first two scholars of the Association were Professor Mary Alice Willcox, of Wellesley College, and Miss Florence Peebles, European Fellow of Bryn Mawr College.

THE late Baron Ferdinand Rothschild has bequeathed to the British Museum art collections valued at $1,500,000.

THE French Society for the encouragement of national industry has been presented with a sum of 20,000 fr. by M. Gilbert.

JUDGE JOHN HANDLEY, of Scranton, Pa., left $250,000 for a public library at Winchester, Va., and made the city his residuary legatee. It has been decided in the Courts that the latter bequest is valid, and the city will receive about $250,000 additional to the public library.

MR. ANDREW CARNEGIE has offered to give $250,000 for the construction of a building for the Washington Public Library if Congress will furnish a suitable site and provide for the maintenance of the library.

THE Imperial Academy of Military Medicine, St. Petersburg, celebrated on December 30th the centenary of its foundation, in the presence of official delegates from Germany, France and other nations. The Director of the Academy, Professor Ponchatine, made an address, giving a brief history of the institution and an account of the work that it had accomplished.

THE Proceedings of the second annual meeting of the Association of Experiment Station Veterinarians, held at Omaha, Neb., September 8, 1898, have recently been published by the U. S. Department of Agriculture (Bureau of Animal Industry, Bul. No. 22). Among the papers are those on 'Growing Tubercle Bacilli for Tuberculin,' by C. A. Cary; 'Feeding Wild Plants to Sheep,' by S. B. Nelson, and 'Laboratory Records for Veterinarians,' by A. W. Bitting.

THE meeting of teachers of chemistry held at the University of Michigan on December 27 and 28, 1898, proved to be of great interest. A considerable number of high schools in Michigan were represented in the meeting. Among the institutions sending teachers were the University of Wisconsin; Lake Forest University; Chicago University; Notre Dame, Ind.; Ohio State University; Kenyon College, Ohio; Otterbein University, Ohio; Olivet College, and Lewis Institute, Chicago. There were also reports and papers from the University of Chicago. The discussions were limited to the subjects and methods of teaching chemistry in high schools and colleges.

AN International Conference on Child Study will be held in Buda-Pesth next September.

IT is reported from Sydney that the private yacht Lady St. Aubyn has discovered some relics of the French navigator La Pérouse at Vanikoro Islands. The objects found include flint-lock muskets and Spanish and French coins.

THE Russian Imperial Geographical Society announces that neither the expedition of Stradling nor of Brede has been able to find in Siberia traces of Andrée. In the meanwhile an expedition has been organized at Copenhagen, under the direction of Dr. Daniel Brunn, to search for traces of Andrée in eastern Greenland

THE Division of Statistics of the U. S. Department of Agriculture reports that the acreage devoted to cotton in the United States in 1897 was 24,319,584, an increase of 1,046,375 over that for 1896. The number of bales produced was in 1897 10,897,857, an increase of 2,365,152 bales. There was an increase in almost every State, being especially noticeable in Arkansas and Indian Territory. The investigation of the amount of cotton purchased by mills located in the cotton-growing States shows that 1,277,674 bales were taken from the current crop. This is 295,683 bales, or 30.1 per cent. more than was purchased by these mills in 1896–97. Without an exception every State

shows increased purchases, the per cent. of increase ranging from 7.7 in Louisiana to 65.2 in Missouri. In the States of greatest consumption the increase is especially marked, that in Alabama being 41.9, in Georgia 25.2, North Carolina 36.6, and South Carolina 33.8 per cent. During the year there were 425 mills in operation, as compared with 402 in 1896–97.

THE Board of Health of New York City has obtained a conviction in the Courts for violating the law forbidding the burning of soft coal, a fine of $25.00 being imposed.

A CORRESPONDENT writes to the London *Times:* "As it is just 100 years since Pestalozzi began at Stanz, on the Lake of Lucerne, the work among the orphan children which so deeply influenced the aims and methods of elementary education in German-speaking Europe and indirectly in Great Britain and America, it is intended to celebrate the centenary by a public meeting, which will be held, by permission of the Council, in the large hall of the College of Preceptors, Bloomsbury-square, on Wednesday, January 4th, at 8 p. m. Though many of Pestalozzi's hopes have been unfulfilled and modern psychology is far from confirming some of his attempted generalizations, his labors at Stanz will always form one of the most inspiring chapters in educational history. His work there emphasized the fact that religious influences are essential to all education which aims at strengthening the will and at elevating character, and that no educational instrument is so powerful as the self-devotion of the teacher. Sir Joshua Fitch will preside at the meeting, at which short addresses will be given by Professor Wilhelm Rein, of the University of Jena; Lady Isabel Margesson; Miss Herford (Manchester), and Messrs. A. Sonnenschein, R. L. Morant, E. Cooke and others."

UNIVERSITY AND EDUCATIONAL NEWS.

THE sum of £115,000 has been subscribed towards establishing a university at Birmingham.

THE late Henry Clark Warren, of Boston, an accomplished Oriental scholar, has left to Harvard University a large sum principally for the Sanscrit department, but including $10,000 for the Peabody Museum of American archæology and ethnology and $10,000 for the Dental School. The Sanscrit department is to have $15,000 for the endowment of the Harvard Oriental Series, and the balance, which is said to be large, is to be used for the benefit of the department.

HARVARD UNIVERSITY receives $5,000 by the will of the late Susan B. Lyman, Dedham, Mass., and $10,000 by the will of the late Mrs. Mary Ann P. Weld, of Boston, the latter sum being for the purpose of founding a Christopher Minot Weld Scholarship, which is to be awarded each year to some worthy student.

THE Teachers College of Columbia University has received an anonymous gift of $10,000.

COLUMBIA UNIVERSITY has established sixty-three benefactors' scholarships and twenty-two faculty scholarships, in order to place the remission of tuition fees hitherto made on a more permanent basis.

THE appropriation of the State for the University of Georgia has this year been reduced by $14,000. The appropriation for the schools has also been greatly reduced.

WE have received the calendar of the Tokyo Imperial University for 1897–98, which is printed in English. There were 2,239 students in the University, distributed as follows: University, 177; the College of Law, 744; College of Medicine, 313; College of Engineering, 386; College of Literature, 279; College of Science, 105; College of Agriculture, 235. There are 90 professors and 41 assistant professors. The library now contains about 223,000 volumes. The *Journal* of the College of Science, established in 1887 and now in its tenth volume, has published many important contributions, which are written in English or in German.

AT Harvard University, Dr. R. W. Willson has been appointed assistant professor of astronomy, and Dr. C. R. Sanger, assistant professor of chemistry.

MR. L. B. WILSON has been appointed demonstrator in pathology and bacteriology in the University of Minnesota.

DR. WILHELM THIERMANN, of the Technical Institute at Hanover, has been made professor.